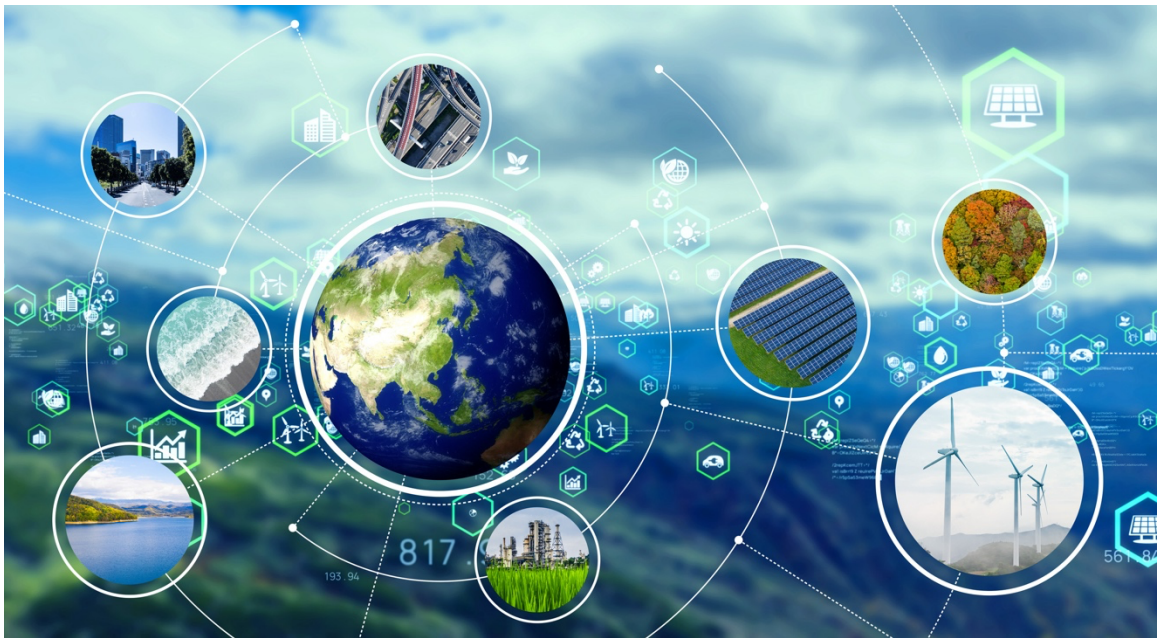
INSTITUTE for GLOBAL ENVIRONMENTAL STRATEGIES

The Environmental Intelligence Marketplace: 12 Companies Innovating the Application of USG Earth Observations Data



A Report Prepared for the
Earthrise Alliance in support of The Earth Genome

By
Nancy Colleton and Rachel Plescha
The Institute for Global Environmental Strategies
Arlington, Virginia, USA

December 2021

The Environmental Intelligence Marketplace: **12 Companies Innovating the Application of USG Earth Observations Data**

Contents

About the Authors

Nancy Colleton *is the President and Co-Founder, Institute for Global Environmental Strategies (IGES), based in Arlington, Virginia, USA. Ms. Colleton has devoted much of her career to promoting Earth observations for environmental information and intelligence. She previously established and led the Alliance for Earth Observations and for seven years served as the co-chair of the Environmental Information Services Working Group (EISWG) of the NOAA Science Advisory Board. As part of the NASA-funded Seeing Green project, she convened business roundtables bringing together NASA and business representatives to explore Earth science applications for the finance, insurance, water, and health sectors. She has also worked closely with the conservation community, serving on the board of IUCN-US (International Union for Conservation of Nature), as the acting chair of Commission on Education and Communication, and was instrumental in launching the global #NatureForAll campaign. Ms. Colleton has been quoted and published in numerous media outlets including The Washington Post, the Boston Globe, The Weather Channel, and Space News. She has served as an early advisor to Skybox Imaging, which sold to Google for $500 million in 2014 and consults with numerous technology startups.*

Rachel Plescha *serves as a Research Assistant at IGES. Ms. Plescha brings research experience on sustainability and climate resilience issues to IGES projects and initiatives. She holds a Master of Public Service and Administration degree focused on environmental policy.*

Citation: Colleton, N. and Plescha, R. (December 2021). The Environmental Intelligence Marketplace: 12 Companies Innovating the Application of USG Earth Observations Data. A Report Prepared for the Earthrise Alliance in support of The Earth Genome. Arlington, VA: Institute for Global Environmental Strategies. Retrieved from https://strategies.org/products/environmental-intelligence-marketplace-report.

The Environmental Intelligence Marketplace: 12 Companies Innovating the Application of USG Earth Observations Data

I. Introduction and Overview

In one of his last interviews, NASA scientist and astronaut, Piers Sellers, likened much of his time as an Earth scientist to "Being an ant trying to understand what an elephant looks like by climbing all over the elephant." As told to Leonardo DiCaprio in the 2016 film, *Before the Flood*, Sellers talks about the illuminating perspective that his time as an astronaut provided him by seeing the Earth from miles above, from space.

We are no longer the ant.

Today's space-based and in situ Earth observations coupled with artificial intelligence (AI) have become so advanced, it not only helps us see the ever-changing Earth—its vast ocean, land mass, and cloud formations—it enables us to see the actual elephant, its herd, the ecosystem where it lives and travels. Scientists can ascertain the temperature of the elephant's surroundings, investigate the availability of water resources and vegetation, identify air quality, and thanks to developments in machine learning and AI, determine patterns in behavior, all of which contribute to better understanding, managing, and protecting the elephant.

As average citizens or business leaders, or government decision makers, we can also protect ourselves, our organizations, and communities by accessing a wealth of environmental information that provides insights on everything from weather to air quality to floods, ocean currents, sea level rise, and wildfires. The vast majority of data that allows these perspectives exists as a result of significant, long-term government investment, which from a space perspective began in the United States in 1960 with the launch of TIROS (Television Infrared Observation Satellite).*

This US Government (USG)-wide investment includes a wide array of assets such as satellites, research vessels, ground-based air quality sensors, autonomous surface vehicles, balloons, drones, and related data management, advanced analytics, and visualization capabilities. USG data are part of a national open data policy, that allows anyone anywhere to access, download, and use the data free of cost.

* The very first satellite that provided images of Earth from space, Explorer 1, was launched slightly earlier in 1958.

The US is not alone. National governments lead the way in deploying Earth observing systems and managing the vast amounts of data they produce. The Group on Earth Observations, (GEO) established in 2003 and with more than 100 national and multinational members, focuses on coordination of these systems and facilitates improving data access, integration, and other efforts that advance science, applications, and decision-making.

Although the current US-GEO Executive Secretary recently stated in an email that, "The USGEO has never attempted to estimate the actual EO expenditures of the federal government, and does not plan to do so," it is clear that the investment is substantial based on the fact that NASA, NOAA, USGS and the other agencies that comprise the USGEO have significant budgets and assets. NASA's Earth science program alone is proposed at nearly $2 billion for FY22.[1] The program includes more than 20 current space-based satellites estimated to produce 4TB of Earth science data each day.[2] NOAA's proposed FY22 budget is nearly $7 billion, with increases of close to $1 billion for science, observations, and forecasting capabilities.[3] An $116.9 million increase in FY22 is proposed for the USGS Land Imaging Program, which recently celebrated the launch of Landsat 9.[4] As described on the NASA's Earth Observatory website:

> Since 1972, eight Landsat satellites have been launched into orbit (including today's launch and excluding Landsat 6, which failed during launch). This joint effort between NASA and the US Geological Survey (USGS) has provided an unprecedented and nearly continuous visual record of Earth's landscapes, icescapes, and coastal waters. Landsat satellites have collected more than 9 million scenes and provoked more than 18,000 research papers.

Such historical records are essential to better understanding and responding to climate change.

One does not need to search far to uncover staggering statistics of weather and climate events impacting the US. NOAA monitors and records weather and climate billion-dollar events. As of 1980, when NOAA started this practice, economic losses total more than $1.975 trillion, an average $47.6B per year.[5]

---

[1] Thomas, W. (2021, July 2). *FY22 budget request: NASA*. Science Policy News from AIP. Retrieved from https://www.aip.org/fyi/2021/fy22-budget-request-nasa.

[2] NASA. (2021, January 26). *NASA Earth Science Data Systems Program highlights 2020*. Earth Data: Open Access for Open Science. Retrieved from https://earthdata.nasa.gov/esds/nasa-esds-highlights-2020

[3] National Oceanic and Atmospheric Administration. (2021, May). *NOAA Blue Book FY 2022*. Retrieved from https://www.noaa.gov/sites/default/files/2021-06/NOAABlueBook2022_final.pdf.

[4] U.S. Geological Survey. (2021, May 28). *FY 2022 Interior Budget in Brief, U.S. Geological Survey*. Retrieved from https://www.doi.gov/sites/doi.gov/files/fy2022-bib-bh059.pdf.

[5] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2021). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73

We live on a planet that is composed of 70% oceans, 31% forests, and is home to 7.8 billion people and 8.7 million species of plants and animals, understanding and responding to weather and climate is only the beginning. The opportunity to provide products and services to navigate a rapidly changing and complex world goes beyond any one government or multi-governmental organization and calls for greater investment, innovation, rapid development and ability to scale found most often in the private sector.

This government-wide investment has produced unparalleled scientific advancements such as the discovery of the ozone hole and the identification of the correlation between the global rise of greenhouse gases such as carbon dioxide and global temperatures that today defines the urgency of climate change. Impacts of climate change coupled with an information-hungry society wanting real-time and locally-focused information products for improved decision making has resulted in demands for environmental intelligence across numerous sectors. It has also provided countless opportunities for private sector companies to leverage the USG's Earth and environmental data sources and related analytic capabilities to deliver environmental insights and intelligence to businesses, consumers, and governments alike.

This report assesses the private sector's use of existing USG Earth observation data and information for innovative business and consumer products. Conducted for the Earthrise Alliance in support of The Earth Genome, the Institute for Global Environmental Strategies (IGES) authors, Nancy Colleton and Rachel Plescha, examine how government-supported Earth observations enable unique insights into and response to challenges on global as well as local scales, across numerous sectors. This report is based on the thesis that the private sector is critical to leveraging and maximizing the investment in USG Earth observations, which is demonstrated through the 12 profiles of the innovative entities listed below.

Company	Sector or Product Focus
BreezoMeter	*Environmental Health Intel/Air Quality, Pollen, Wildfires*
Climate Trace	*GHG Monitoring*
Cloud to Street	*Flood Monitoring and Forecasting*
FernLeaf Interactive	*Climate Services, Municipal Market, Resilience*
First Street Foundation	*Flood Monitoring, Climate Services*
Impact Observatory	*Global Development*
Jupiter Intelligence	*Climate Intelligence and Services*
Pachama	*Forestry, Carbon Offsets*
Orbital Insight	*Broad Geospatial Analytics, Supply Chain Transparency*
The Climate Service	*Climate Services, Finance, Climate Disclosure*
Tomorrow.io	*Weather and Climate Intelligence*
True Elements	*Water*

It is important to note that the 12 exemplar companies profiled for this report conduct data applications. They do not or have not at the time of this report, launched hardware systems or have data collection as their primary mission. Earth observation companies such as Maxar, Planet, and Airbus and many others are established providers of satellite imagery and data products. More recently, private sector offerings have also included more in situ observations by companies such as Saildrone, which provides oceangoing autonomous surface vehicles and made a major splash most recently by capturing for the first time ever real-time video inside category four hurricane, Sam. In as much as these organizations have advanced the capabilities to better understanding Earth processes and have made significant contributions to government-sponsored science, their main focus is data collection. This report looks at a different angle: examining companies that are leveraging USG investment for new innovative products and services. They are exemplars in a much larger landscape of companies.

In an effort to be as transparent as possible, it is important to note that co-author, Nancy Colleton, consults with BreezoMeter and has long-standing professional relationships with numerous representatives of companies included in this study. In addition, the funding source for this project, the Earthrise Alliance, is also an active participant in Climate TRACE.

Following this introduction, the Technical Approach summarizes the expert interviews, describes the market news and literature review, and presents findings and observations. In addition, it presents assessment criteria or the method used for identifying the exemplar companies. The Exemplar Companies are presented in the third section with detailed summary information on each company included in *Appendix A*. The Bibliography is presented in *Appendix B*.

II. Technical Approach

As noted in the previous section, this report explores how the private sector leverages existing USG Earth observations investment for new innovative intelligence products. The objective was to research, identify, and describe 12 companies (originally 10 companies) that currently or are poised to exploit the use of USG Earth observations data and information. This research is based on three questions:

1. How are companies changing the application of USG-acquired EO data?
2. Who are some of the companies that are making significant impact and how?
3. What attributes of these companies exist that have led to their success?

Five activities comprise this research and include:

- Conducting expert interviews;
- Reviewing market news and current literature;
- Identifying general observations and findings;
- Developing assessment criteria; and
- Identifying and summarizing exemplary companies.

Each of the activities is described in the following paragraphs.

Expert Interviews

Surveying subject matter experts was major part effort. Although interviewing 10 experts was originally planned, the list rapidly grew as experts recommended and connected the authors with others with which to talk. The interest these experts showed for the topic is illustrative of the excitement and investment in the EO sector at present.

The following experts were interviewed for this project:

1. **Steven Ambrose**, Chief Climate Scientist, SAIC
2. **Steven Brumby**, Ph.D., Founder, Impact Observatory; Senior Advisor for Data Vizualization, National Geographic Society; and Co-founder, Descartes Labs
3. **Lawrence Friedl**, Director, Applied Sciences Program, Earth Science Division, NASA
4. **Timothy Gallaudet**, Ph.D., Rear Admiral (Ret), President, Ocean STL Consulting, LLC; and former acting NOAA Administrator
5. **Jeff Hicks**, CEO, Fernleaf Interactive
6. **Dan Hammer**, Ph.D., Managing Partner, Earthrise Media
7. **Patt Harr,** Ph.D., Science Fellow**,** Jupiter Intelligence

8. **Edward J. Kearns**, Ph.D., Chief Data Officer, First Street Foundation; former Chief Data Officer, US Department of Commerce and NOAA.
9. **Jason Kessler**, Program Executive, SBIR, NASA
10. **Keith Massback**, Principal Consultant, Plub Run LLC; Angel Investor and Advisor; former Executive Director, US Geospatial Intelligence Foundation (USGIF)
11. **Anne Miglarese**, Program Executive Officer, Impact Science, Saildrone
12. **Steve Moran**, Senior Director for Government Relations, Spire
13. **Bruno Sanchez-Andrede Nuno**, Planetary Computer Program Director, Microsoft
14. **Mack Pearsall**, CEO, PVC, Inc.; key investor The Collider and The Climate Service
15. **Kevin O'Connell**, Founder & CEO, Space Economy Rising; former Director, Office of Space Commercialization, US Department of Commerce
16. **Will Sarni**, Founder and CEO, The Water Foundry
17. **Ned Snell**, Ph.D., Executive Vice President, AER (Atmospheric and Environmental Research, Inc.), a Verisk Business
18. **David Skole,** Ph.D., Professor, Michigan State University; Founder, Carbon2Markets
19. **Dan Stillman**, Marketing Director, Tomorrow.io
20. **Michael Tanner**, President, Tanner Group International; former Director, NOAA Center for Weather and Climate; and Senior Program Manager, Group on Earth Observations (GEO)
21. **Walter Scott,** CTO, Maxar
22. **Paul Walsh**, U.S. General Manager, Breezometer; former Weather Company Executive and Global Director of Weather, IBM

News Reports and Literature Review

More than 75 media and literature sources informed this research in addition to the expert interviews. Three articles are of note and include:

- "These Are The Startups Applying AI To Tackle Climate Change" (Rob Toews, *Forbes*, June 20, 2021, and recommended by Dan Hammer);
- "Can Asheville become more than beer and bears?" (Tom Fiedler, *Asheville Watch Dog*, April 26, 2021); and
- "Global water crises unleash tsunami of watertech" (Elle Brunsdale, *Climatetechvc.org*, July 23, 2021).

"These Are The Startups Applying AI To Tackle Climate Change" was one of the most informative articles. It identifies 38 startup companies that are applying AI for numerous business areas such as climate intelligence and precision agriculture. Given that AI requires extensive amounts of data, it is not surprising that several of these companies require Earth observations for their products. In addition, the article also provided excellent background on market size, venture funding sources, and insight into business

models. Because of the valuable information provided by this article, the table below provides a complete list of companies mentioned by category.

These Are The Startups Applying AI To Tackle Climate Change
Rob Toews, Contributor, ***Forbes****, June 20, 2021*

Climate Intelligence
1. One Concern
2. Jupiter Intelligence
3. Cervest
4. ClimaVision
5. Gro Intelligence
6. ClimateAI
7. Terrafuse AI

Climate Insurance
8. Descartes Underwriting
9. Arbol
10. Kettle
11. Understory
12. Cloud to Street

Carbon Offsets
13. Pachama
14. NCX
15. Patch
16. Watershed
17. Emitwise
18. SINAI Technologies
19. Persefoni
20. CarbonChain

Buildings
21. BrainBox AI
22. 75F
23. Nomad Go

Precision Agriculture
24. Ceres
25. Hummingbird Technologies
26. Gamaya
27. Prospera
28. Semios
29. Arable
30. FarmWise
31. Bear Flag Robotics

Renewables and The Grid
32. Invenia
33. Gridware
34. Raptor Maps
35. Materials Zone

Fires
36. Pano AI
37. Fion Technologies
38. Firemaps

A number of the companies identified in the *Forbes* article were also businesses that this project's experts identified through interviews. However, this report looks beyond climate change and AI and the *Forbes* article served only as a starting point for identifying the exemplar companies and potential sectors served by each.

Appendix B, Reference Information, includes a complete list of sources used for this report.

Findings and Observations

As a result of the expert interviews coupled with the news reports and literature review, several findings and observations were identified and are presented below.

1. **The EO applications marketplace is changing rapidly with climate change and sustainability driving urgent demand.**

   As noted by Andrew Freedman of *Axios* on October 2, 2021:

- In recent years, money has begun pouring into startups that aim to help businesses get a better handle on their climate change-related risks.
- Already in 2021, this venture investment has reached a record $584 million globally, with most of the funding (about $437 million) concentrated in the United States, per Pitchbook data.
- These companies' missions range from generating, collecting and analyzing data to more specific services like tracking supply chain vulnerabilities, agricultural forecasts and more.

While coverage of value-added, data analytic companies are often overshadowed by media reports of huge investment in new technology systems such as last summer's announcement of The Rise Fund's $100 million investment in Climavision or the close of a $100 million Series C funding round for Saildrone in October. However, with the recent announcement of a $50 million investment in Jupiter Intelligence, more media reports of data applications for intelligence investments are gaining recognition. As reported by *Reuters* on December 7, 2021, Tomorrow.io "will go public through a merger with a blank-check firm in a deal worth $1.2 billion, the companies said on Tuesday." The report goes on to state, "The deal with special purpose acquisition company (SPAC) Pine Technology Acquisition Corp (PTOC.O), which is expected to close the first half of 2022, will fetch up to $420 million for in proceeds for Tomorrow.io."

2. **The combination of GIS, Cloud Computing, and AI enable this transformation.**

Numerous experts interviewed for this report noted the combination of GIS, cloud computing, and AI have truly advanced application of EO data. Companies such as BreezoMeter, Tomorrow.io, Jupiter Intelligence and others provide hyper-local intelligence products that can only be achieved with the combination of these three technologies. This point is further supported by Will Sarni, founder and CEO of the Water Foundry who stated to *Aquatechtrade.com on October 21, 2020*: "EOS technology solutions alone are not a game-changer for both the public and private sectors in managing water quality and quantity." He adds, "When coupled with other digital technologies such as AI, however, they create more resilient and sustainable water strategies across the "digital water value chain" – from the watershed, in operations and connecting with consumers."

3. **The USG Open Data Policy is Essential**

All 12 companies represented in the list of exemplars rely on free and open data from the USG. Federal geospatial data and satellite images are integrated into the organization's products and services using AI, machine learning, models, and other various data analytic methods. Each company also pulls supplemental mission-specific data from other free sources when appropriate, such as traffic data, insurance reports, citizen science, and other government-sponsored and commercial

satellite images. Without the magnitude of freely-available data, these companies would not be as successful.

- Cloud to Street's Global Flood Database relies on NASA satellite data, NOAA flood reports, and Google Earth Engine.
- True Element's water quality forecasting platform relies on hundreds of US federal and local databases pulling from 1.5 million sensors, as well as pollution discharge permits from the EPA and hydrologic Unit Codes from USGS.
- The Climate Service's Climanomics software platform feeds socioeconomic data from IPCC, NASA, and NOAA into their climate model projections to understand the cost of climate risk.

4. **Domain expertise is critical**

One of the most prominent themes shared by the experts interviewed for this report is that deep domain expertise is critical to the success of any these private sector environmental intelligence endeavors. Each pointed out that as much as the USG has an open data policy, understanding what data is available, where to find it, and ultimately how the data or analytics can be used or *not used* is essential. Therefore, in almost every case, each of these companies has employed or engaged former USG data science experts. Here are several of those vital connections:

BreezoMeter—NOAA Connection—Chief Scientist, Dr. Gabriela Adler Katz, did her post doc work at NOAA's Earth Systems Research Lab in Boulder, Colorado.

Climate TRACE—NASA Connection— Former Deputy Administrator of NASA, Lori Garver now serves as the CEO of Earthrise Alliance, one of the members within Climate TRACE's coalition. Earthrise Alliance Founder and Partner, Dan Hammer, previously worked at NASA as a Presidential Innovation Fellow, was a Senior Policy Advisor at the White House for the Obama Administration, and co-founded Global Forest Watch at the World Resources Institute (WRI).

Cloud to Street—NASA Connection—Director of Innovation Colin Doyle previously worked at NASA's Goddard Space Flight Center Hydrological Sciences Laboratory as the Center Lead for the NASA DEVELOP National Program.

FernLeaf Interactive— NOAA Connection — CEO, Jeff Hicks, and Sr. Resilience Associate, Jim Fox, both were instrumental in working with NOAA NCEI in Asheville, North Carolina to develop the US Climate Resilience Toolkit. FernLeaf also located in close proximity to NCEI and, like the Climate Service, was part of a locally-funded incubator (The Collider) to leverage Asheville's rich climate data resources.

First Street Foundation— NOAA Connection— formerly a Chief Data Officer for both NOAA and the US Department of Commerce, Dr. Ed Kearns, now serves as First Street's Chief Data Officer.

Impact Observatory— DOE Connection — CEO and Co-Founder Dr. Steven Brumby previously worked as a scientist at Los Alamos National Laboratory. Brumby also currently serves on the Department of Interior's National Geospatial Advisory Council's Landsat Advisory Group.

Jupiter Intelligence— Multiple Connections — Pat Harr, Senior Weather Analyst and Science Fellow previously served as Atmospheric Section Head at the National Science Foundation. Notable advisors include Sherri Goodman, former Deputy Undersecretary of Defense for Environmental Security and Todd Stern, former United States Special Envoy for Climate Change. Staff have also been employed at NOAA, NSF, NASA, the CIA, the Department of the Treasury and the Department of State before joining Jupiter Intelligence.

Orbital Insight— NASA Connection — Founder, Chairman, and CTO James Crawford managed robotics at the NASA Ames Research Center.

Pachama —NASA Connection — Carlos Silva, Science Lead for Pachama, was a postdoctoral researcher with the NASA Global Ecosystem Dynamics Investigation (GEDI) program at the University of Maryland.

The Climate Service—NOAA Connection—CEO and Founder, James McMahon spent six years as a senior advisor at NOAA's Center for Environmental Information in Asheville, North Carolina, previously known as the National Climatic Data Center (NCDC). McMahon is joined by Advisor, Dr. Tom Karl, who served as NCDC's director as well as the Director of the US Global Change Research Program.

Tomorrow.io— NOAA Connection — Advisors include Kathryn Sullivan, PhD, former NOAA Administrator and NASA astronaut; Rear Admiral Tim Gallaudet, PhD (Retired) former NOAA Deputy Administrator; Marshall Shepherd, PhD, Director, UGA Atmospheric Sciences Program; and Keith Masback, former Executive Director, USGIF.

True Elements — DoD Connection —Chuck Louisell, Ph.D., Chief Artificial Intelligence Officer, has extensive experience via Cisco Systems and DoD.

5. Partnerships are vital to success and scaling

Strategic partnerships benefit many of the 12 exemplar companies by expanding reach and use of products. Several examples include:

- BreezoMeter established a business-to-consumer model in partnership with Apple. The Apple iPhone weather app integrates BreezoMeter's hyperlocal air quality data, which broadens BreezoMeter's reach to more than 400 million people worldwide.
- FernLeaf Interactive works in a public-private partnership with UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC). NEMAC provides essential research to FernLeaf, which allows both organization to support more resilience projects across federal, state, and local governments as well as the private and non-profit sector. With the research support provided by NEMAC, FernLeaf Interactive has been able to partner with NOAA and USFS and contribute to their federal efforts.
- First Street Foundation's Flood Factor information has been integrated in to realtor.com's website. Realtor.com receives more than 100 million website views a month and includes Flood Factor's flood risk information as part of their "Neighborhood" tab. Other real estate platforms such as Redfin and Estately have followed suit, making Flood Factor a popular and useful tool when evaluating properties.
- Impact Observatory is partnered and works closely with Esri. The use of Esri ArcGIS allows for 10 million users to access land use and land cover maps that Impact Observatory creates from satellite data. Impact Observatory has also partnered with the United Nations Development Programme, the National Geographic Society, and Microsoft AI for Earth, further expanding the use and views of their highly detailed maps.

6. Hybrid business models are emerging

A notable attribute that has led to success of many of our exemplar companies is the adoption of a hybrid model. Instead of following traditional organization, many of our exemplars combine different partners, customer relationships, and products to access different sectors of the marketplace.

- Climate TRACE is not one company, but a coalition of 11 members whose combined efforts result in a radically transparent emissions inventory. Using 11,000 sensors, Climate TRACE's hybrid model allows for GHG emissions tracking across 10 sectors and 38 industries on a scale that would not be feasible for one organization to complete alone.
- Tomorrow.io uses a hybrid model to their advantage by tailoring products for different sectors and users. Tomorrow.io originally offered a weather app for

the day-to-day users while providing business to business weather and air quality platforms. In addition to these private sector-oriented products, Tomorrow.io also has embarked on building and launching a satellite constellation, which is a supported by the US Air Force. It intends to launch 32 satellites and has recently added a weather and climate security platform software to their portfolio. The variety of these products illustrates how Tomorrow.io has successfully grown from a primary focus on data analytics to now procuring their own satellite system.

- First Street Foundation is a 501(c)(3) nonprofit research and technology group providing data, supporting and publishing research, and managing the online tool, Flood Factor. The hybrid model of First Street Foundation relies on the contributions from the Research Lab, made up of 180 researchers from 42 academic institutions, to support publicly accessible flood risk information through the Flood Factor platform.

7. **The "Blue Economy" presents a wave of opportunity**

As noted earlier in the report, NOAA's proposed FY22 budget has increased funds for science, observations, and forecasting capabilities. Specifically, NOAA requested an additional $368.2 million to invest in their observational network. The NOAA Administrator, Richard Spinrad, in his May, 2021 testimony before the United States Senate Committee on Commerce, Science, and Transportation, highlighted the importance of government-provided operational and actionable environmental information and data for the private sector. Spinrad hopes to encourage private sector organizations who use and provide climate data information products and services, specifically noting First Street Foundation as a prime example. Climate information products based on ocean and climate data are key components of what Spinrad distinguishes as the "New Blue Economy." NOAA plans to support the new blue economy with publicly available data, defining the sector as a "knowledge-based ocean economy" where data about the ocean is used to inform other sector's decision-making as well as promote sustainable economic development and create new products, services, and businesses. Promoting the "New Blue Economy" is one of Spinrad's top priorities for NOAA, which signals additional opportunities for the Earth observation companies and the use of ocean and climate data for the private sector.

Assessment Criteria for Identifying Companies

The starting point for identifying the companies that currently *or* are poised to exploit the use of USG EO information is exactly that—the company must use USG EO to create its product or service.

Once beyond the threshold of the company being dependent on USG EO data for their product or service, two other discriminators are considered:

- Is the company already a recognized transformational leader in the EO sector?
- Is data collection its primary mission?

For example, many companies are obvious transformational leaders in the EO sector and are essential to discovery, analysis, and application of USG EO. This is the case for cloud computing providers such as Amazon Web Services, Google Cloud Platform, and Microsoft Azure. These companies have already demonstrated their significant contributions and advances to accessing and analyzing EO data and are not included in this list.

Another such case is GIS leader, ESRI. It is in the critical path of many EO applications and given its market share globally, is recognized as an integral part of the private sector leveraging USG EO. Private sector cloud computing and GIS capabilities are threads throughout this next wave of applications.

In addition, companies that have data collection or development of data collection systems as their primary mission—whether space-based, airborne, or in situ—are not included on this list. ClimaVision, Saildrone, Spire, and others have received significant private investment and press recently and have made important contributions to USG programs. ClimaVision recently received $100 million of private equity funding by The Rise Fund as reported by *Businesswire* on June 2, 2021. Saildrone is revolutionizing ocean measurements from uncrewed surface vehicles, is working in close partnership with NOAA, and is estimated to have received more than $120 million in private investment. Spire, which became a publicly traded company on August 17th raised $265 million as reported in *Space News*.

It is also important to note that commercial imagery and data providers such as Maxar and Planet are significant users of USG data given it is used to calibrate their products.

During an interview as part of this study, Rear Admiral (ret) Timothy Gallaudet, Ph.D., president, Ocean STL Consulting, LLC and former acting NOAA Administrator, stated his enthusiasm for these companies that are "acquiring data for the government" noting that he's seen first-hand their contributions. Whether Saildrone's fishery survey for catch limits or Spire's radio occultation data, Gallaudet emphasized the growing role of commercial companies in contributing to USG operations thanks to policy changes and other mechanisms that make it easier to tap into the growing offerings of commercial data resources. It is not clear at this point whether commercially-developed data application products such as those created by Jupiter Intelligence, BreezoMeter, and others will have the same entre into the Federal marketplace as those acquired through commercial data buys.

As this research attempted to identify entities that produced relatively new innovations using USG data and related science assets, a broad landscape was considered. Each of the companies is assessed against the following criteria:

- ***Demonstrated use of USG EO***—Is the business model dependent on the use of USG EO data and information?
- ***Magnitude or scale of the problem to be solved***—Does the use or application of the USG data have significant impact either economically or socially?
- ***New idea or advantage***—Does the company possess a radically new idea or advantage to leverage USG EO data and information?
- ***Domain expertise & Leadership***—Does the company possess deep domain expertise (people with deep EO knowledge and experience) is critical to leveraging these data sources? Does the company's leadership demonstrate a realistic and inspiring vision?
- ***Support***—Does the company have an established funding source required for near and/or long-term product/service development.

In addition to assessing the companies against the criteria identified above, an effort was made to identify companies provided a diversity of services and sectors, to obtain a greater appreciation for the broad landscape. This was done so that not all companies would fall into on single category such as climate services or agriculture.

It is also important to note that this list includes startups as well as established companies.

III. 12 Exemplar Companies Innovating Application of USG Earth Observations Data

Based on the criteria identified and described in the previous section, our research identified 12 exceptional examples of companies innovating application of USG Earth observations data. The group includes:

Company	Sector or Product Focus
BreezoMeter	*Environmental Health Intel/Air Quality, Pollen, Wildfires*
Climate Trace	*GHG Monitoring*
Cloud to Street	*Flood Monitoring and Forecasting*
FernLeaf Interactive	*Climate Services, Municipal Market, Resilience*
First Street Foundation	*Flood Monitoring, Climate Services*
Impact Observatory	*Global Development*
Jupiter Intelligence	*Climate Intelligence and Services*
Pachama	*Forestry, Carbon Offsets*
Orbital Insight	*Broad Geospatial Analytics, Supply Chain Transparency*
The Climate Service	*Climate Services, Finance*
Tomorrow.io	*Weather and Climate Intelligence*
True Elements	*Water*

An effort was made to identify companies representing a variety of services and sectors. Although all chosen considering the same criteria, this list includes a diverse group of organizations producing unique products and spanning multiple sectors. They are presented as exceptional examples, considering a broad landscape. The list could easily have included many more companies, but the intent of this list was to identify examples of applications and in no ranked order.

Business models range from nonprofit 501(c)(3)s, public-private partnerships, traditional ".com's" and coalitions.

Most of the organizations are located in the United States, with the exceptions of BreezoMeter, which is headquartered in Israel, and Climate TRACE, which is a coalition and has no physical location.

The majority of the companies promote an online platform of some kind, either as a business-to-business software or as a business-to-consumer feature (often both).

In accordance with the criteria of excluding already recognized leaders of the EO sector, all of these companies have been founded within the last eight years. The oldest company, Orbital Insight, was founded eight years ago in 2013.

Irrespective of age, these organizations have been successful in securing funding and investment. Based on the availability of data, the low-end estimate of the current amount invested into all 12 organizations totals approximately $600 million USD. A list of supporters and investors identified per their individual company websites or other resources is provided below.

Alphabetical List of Investors

Agence Francaise de Development
Aglaé Ventures
AirAngels
Alphabet
Amazon's Climate Pledge Fund
Association of International Certified Professional Accountants (AICPA)
AxessVentures
Balyasny Asset Management (BAM)
Bloomberg BETA
BMNT
Breakthrough Energy Ventures (Bill Gates' investment firm)
Bunge
CDPQ
Chevron
Citizen.vc
Clearvision Ventures
CME Group
DCVC (Data Collective)
Draper Richards Kaplan Foundation
Energize Ventures
Energy Ventures
Entrée Capital
Envision Ventures
Eurazeo
Fortissimo Capital
Geodesic Capital
Goldacre
Goldman Sachs
Google Ventures
Grantham Foundation
HELLA Ventures
Highline Capital Partners
Hightide Foundation
Idinvest Partners
Ignition Partners
Imagine H2O
In-Q-Tel
Intellectus
Invicta
ITOCHU Corporation
JetBlue Technology Ventures
JumpSpeed Ventures
Launchpad Digital Health
Liberty Mutual Insurance
Liberty Mutual Strategic Ventures
Lowercarbon Capital
Lux Capital
MCJ Collective
MPower Partners
MS& AD Ventures
My Climate Journey
OATV
Persei Venture LLC
Pitango Venture Capital
Plug 'n' Play Ventures
QBE Ventures
Saltwater
Schwab Charitable Fund
Sequoia Capital
SKY Perfect JSAT Group
SN Energy
Social Capital
Square Peg Capital
Stonecourt Capital
Sweet Capital
Synovia Capital
SYSTEMIQ
The Miller Center for Social Entrepreneurship
Tech Pioneers Fund
ThirdKind Ventures
Xplorer Capital
Y Combinator
2040 Foundation

These companies are certainly making an impact in the Earth observation data application marketplace. More specific data on each of these companies can be found in the included *Appendix A*.

IV. Summary & Conclusions

The objective of this project was to research, identify, and describe 12 companies that currently or are poised to exploit the use of USG Earth observations data and information. Given that objective and ensuing research, it is safe to say that there are numerous companies that are successfully leveraging government investment in Earth observations for economic, social, and public good, and in some cases, a combination.

The sound science provided by the USG is further enhanced across numerous sectors and domains. Where this report profiles 12 companies, it is essential to recognize that this is a small fraction representative of a much larger landscape that is changing rapidly with unlimited potential. Based on available data, it is estimated that more than $600 million of private investment in the 12 companies recognized as of 2013.

The success of these companies demonstrates how quickly the private sector can develop products, scale efforts, and deliver products and services to consumers and businesses alike.

Given where the application of USG EO data for environmental intelligence stands at this time, it does raise several important and related questions:

- Could more be done to help facilitate the use of this data by the private sector?
- Should US Open Data Policy represent the end or beginning of facilitating USG data use?
- Who within the USG is responsible for monitoring this marketplace to ensure amongst other things that the new environmental intelligence products and services are adopted, not replicated by the Federal government?

In a recent briefing to a senior Administration official, the question was asked, “Why don’t I know about these companies?” This was a similar response when USG representatives were asked to identify companies that might be researched for this report. Other than the First Street Foundation, these companies were not known to USG representatives contacted for this report.

With the pending infrastructure funding coupled with a rise in climate-related events impacting the United States, the need for “all hands-on deck” approach to providing the best intelligence for America’s and the planet’s future. This applies to everything from building stronger and safer homes, roads, and bridges to siting renewable energy operations to reporting on air pollution and greenhouse gases in the atmosphere to making America’s coasts more resilient to climate change. This will not happen without Earth observations and clearly not without innovative private sector applications.

Therefore, the most important lesson learned from this research may be that the USG should do more to understand and engage with the private sector to ultimately encourage greater innovative application of its data.

Appendix A

BreezoMeter

"In many countries, people don't have a clue about the air around them"
-Korber qtd. by McCarthy, 2021[6]

Mission:	To improve the health of billions of people around the world with real-time, location-based, actionable air quality data
Founded:	2014
Headquarters/Offices:	Haifa, Israel and San Jose, California USA
Leadership:	Ran Korber, CEO & Co-Founder Emil Fisher, CTO & Co-Founder
Product(s):	Air Quality, Pollen, Wildfire Tracking, Weather
Sectors:	Health, Weather & Climate, Environmental Intelligence

BreezoMeter provides accurate, trusted environmental intelligence down to street-level resolution on air pollution, pollen, wildfires, and weather forecasts. Their mission is to "provide real-time, location-based, actionable air quality data" as accessible and actionable environmental data and insights for individuals so that they are empowered to make healthier decisions.[7] In 2015, BreezoMeter was recognized by both the US White House and by the UN Economic Commission for Europe for their groundbreaking efforts.[8,9,10]

BreezoMeter's business-to-business efforts include work with companies such as Bosch, L'Oreal, Volvo, Astrazeneca and others.[11] They also have a business-to-consumer model in partnership with Apple.

---

[6] McCarthy, M. (2021, June 28). *Breezometer, the iPhone Tool that measures air quality, raises a $30M Series C*. TechCrunch. Retrieved from https://techcrunch.com/2021/06/28/breezometer-the-iphone-tool-that-measures-air-quality-raises-a-30m-series-c/.

[7] Elkabetz, D. (2020, January 2). *The top 5 questions we get about Breezometer's air quality data*. BreezoMeter Blog. Retrieved from https://blog.breezometer.com/top-5-questions.

[8] Shamah, D. (2015, May 10). *Israeli pollution app entrepreneurs to be feted at White House*. Current Top Stories. Retrieved from https://www.timesofisrael.com/israeli-pollution-app-entrepreneurs-to-be-feted-at-white-house/.

[9] Udasin, S. (2015, May 12). *Founders of israeli air pollution app breezometer attend White House*. Business & Innovation. Retrieved from https://www.jpost.com/business-and-innovation/tech/founders-of-israeli-air-pollution-app-breezometer-attend-white-house-402867.

[10] Bletter, D. (2021, November 1). *How a search for clean air turned into the world's Favorite pollution app*. ISRAEL21c. Retrieved from https://www.israel21c.org/how-a-search-for-clean-air-turned-into-the-worlds-favorite-pollution-app/.

[11] Powell, K. (2021, October 7). *BreezoMeter Provides Outdoor Environmental Intelligence for Better In-Cabin Air Quality for Volvo Cars*. Yahoo! Finance. Retrieved from https://finance.yahoo.com/news/breezometer-provides-outdoor-environmental-intelligence-120600974.html?guccounter=1.

Impact: The World Health Organization (WHO) estimates that air pollution kills seven million people worldwide every year and that 91% of the world's population live in places where air quality exceeds WHO guideline levels for public health.[12] BreezoMeter provides an accessible way for the public worldwide to understand air quality information the same way consumers today check weather.[13]

Advantage: A partnership with Apple delivers BreezoMeter's highly-accurate, hyper-local health focused data (air pollution, pollen, and wildfire) to more than 335 million people worldwide, filling a global health need.[14]

Data: Their advanced data analytics ingests NASA, NOAA, and EPA data products, other non-US government sources and monitoring stations, low-cost sensors, satellites, meteorological data, live traffic, and land cover information.

Domain expertise: Both co-founders Ran Korber and Emil Fisher, CEO and CTO respectively, have backgrounds in environmental engineering, environment, and hi-tech projects. BreezoMeter employs approximately 60 scientists with expertise in atmospheric science, turbulent flow, and convection. They also have a scientific leadership team with domain expertise including Paul Walsh, former Global Director of Climate and Sustainability at IBM and Dr. Gabriella Adler, a former NOAA research scientist.[15]

Support: In June 2021, BreezoMeter closed Series C funding round with $30 million, bringing their total investment to date up to $45 million.[16,17] Investors include JumpSpeed Ventures, Launchpad Digital Health, AxessVentures, Eurazeo, Entree Capital and Fortissimo Capital.

---

[12] World Health Organization. (2021, September 22). *NEW WHO global air quality guidelines aim to save millions of lives from Air Pollution*. World Health Organization. Retrieved from https://www.who.int/news/item/22-09-2021-new-who-global-air-quality-guidelines-aim-to-save-millions-of-lives-from-air-pollution.

[13] Drenik, G. (2021, September 9). *This Company Is Making Sure People Check Air Quality As Much As They Do Weather*. Forbes. Retrieved from https://www.forbes.com/sites/garydrenik/2021/09/07/this-company-is-making-sure-people-check-air-quality-as-much-as-they-do-weather/?sh=49df1a0f4aeb.

[14] Wrogel, S. (2021, October 13). *With tools tracking air pollution, Israeli start-up hopes to 'democratize environmental data'*. Retrieved from https://www.algemeiner.com/2021/10/13/with-tools-tracking-air-pollution-israeli-start-up-hopes-to-democratize-environmental-data/.

[15] Korber, R. (2021, September 1). *What's been happening at Breezometer since our funding announcement!?* What's Been Happening at BreezoMeter Since our Funding Announcement!? Retrieved from https://blog.breezometer.com/breezometer-2-months-after-fundraising.

[16] Business Wire. (2018, September 13). *Breezometer Closes series B fundraising with $7.75M USD*. Retrieved from https://www.businesswire.com/news/home/20180913005402/en/BreezoMeter-Closes-Series-B-Fundraising-with-7.75M-USD.

[17] Korber, R. (2021, June 28). *Breezometer Closes Series C with $30M for health-focused environmental intelligence*. BreezoMeter Closes Series C with $30M for Health-Focused Environmental Intelligence. Retrieved from https://blog.breezometer.com/breezometer-closes-series-c-with-30m.

Climate TRACE

"There's an old saying that you can only manage what you can measure"
-former Vice President Al Gore qtd. By Peters, 2021

Mission:	To harness satellite imagery and other forms of remote sensing, artificial intelligence, and collective data science expertise to track human-caused GHG emissions as they happen
Founded:	2020
Product(s):	Global Emissions Monitoring, Climate Intelligence
Sectors:	Environmental Intelligence

Climate TRACE is a coalition of 11 members which includes nonprofits, tech companies, universities, and former Vice President Al Gore. The TRACE acronym stands for "Tracking Real-time Atmospheric Carbon Emissions."

Founded in July 2020, with its first data release in September 2021, Climate TRACE's mission is to "harness satellite imagery and other forms of remote sensing, artificial intelligence, and collective data science expertise to track human-caused GHG emissions as they happen." Their real-time emissions inventory is intended to be used for pollution management and support decision-making on environmental policy, investment, and corporate sustainability strategies.[18,19] TIME Magazine recognized Climate TRACE's analytics tool and data portal as one of "The Best Inventions of 2020."[20]

Impact: Per their website, Climate TRACE provides "Radical Transparency for global emissions." Most GHG emissions data relies on outdated, self-reported numbers from polluters that undercount the extent of their emissions, leading to a significant difference between reported numbers and reality.[21] Instead of a source-by-source basis or self-reporting regimes, Climate TRACE uses satellite data,

[18] Bender, B., & Custodio, J. (2021, October 31). *'It is a game changer': Waging War on climate change from space*. Energy & Environment. Retrieved from https://www.politico.com/news/2021/10/31/climate-change-space-satellites-517773.
[19] Climate TRACE: The Source. (2021, September 16). *Climate TRACE releases first comprehensive, Independent Database of Global Greenhouse Gas Emissions*. Medium. Retrieved from https://medium.com/climate-trace-the-source/climate-trace-releases-first-comprehensive-independent-database-of-global-greenhouse-gas-emissions-718822862862.
[20] TIME Magazine. (2020, November 19). *Climate TRACE: The 100 best inventions of 2020*. The Climate Cop: Climate TRACE. Retrieved from https://time.com/collection/best-inventions-2020/5911362/climate-trace/.
[21] Lieberman, B. (2021, March 31). *Climate trace to track real-time global carbon emissions* . Yale Climate Connections. Retrieved from https://yaleclimateconnections.org/2020/08/climate-trace-to-track-real-time-global-carbon-emissions/.

sensors, and AI to independently measure emissions to get more complete, accurate, and timely data.[22,23]

Advantage: The quality and domain expertise of each of Climate TRACE's collaborators and partners in the coalition allow for global GHG emissions tracing across 10 sectors that would otherwise be impossible for one company to do on their own.[24,25] Each member has their own focus, strength, and technological background (Ocean Mind focuses on shipping, RMI focuses on oil and gas)[26] that they bring together to create a comprehensive platform that allows GHG emission data to become useful to more sectors and organizations at all levels (from Paris climate agreement to individual factories, ships and power plants).[27]

Data: Climate TRACE develops their GHG emissions data using AI, machine learning, and satellite image processing from 300 satellites and 11,000 sensors.[28] Their inventory incorporates free and open earth observation data sources including USGS, EPA, ESA and NASA.

Domain Expertise: Former Vice President Al Gore is the most prominent climate expert of Climate TRACE's members which also includes Dan Hammer, a former Senior Policy Advisor in the Obama White House and a Presidential Innovation Fellow at NASA, as well as Former Deputy Administrator of NASA, Lori Garver, CEO-both of Earthrise Alliance.[29,30] Each member organization also contributes domain expertise ranging from Google data pipeline engineers, climate scientists, fisheries analysts, sustainable financial advisors, and more to the coalition.

Support: A $1.7 million grant to Climate TRACE's WattTime and Carbon Tracker

---

[22] Kerber, R. (2021, September 16). *Al Gore-backed climate project to track emissions in real-time*. news.trust.org. Retrieved from https://news.trust.org/item/20210916040037-gtrv1/.
[23] Freedman, A. (2021, September 16). *Al Gore's climate trace tracking group finds vast undercounts of emissions*. Energy & Environment. Retrieved from https://www.axios.com/global-carbon-emissions-inventory-surprises-cb7f220a-6dfd-4f88-9349-5c9ffa0817e9.html.
[24] Peters, A. (2021, September 16). *This Al Gore-backed project found that we're seriously undercounting greenhouse gas emissions*. Fast Company. Retrieved from https://www.fastcompany.com/90677559/this-al-gore-backed-project-found-that-were-seriously-undercounting-greenhouse-gas-emissions.
[25] O S Chegwidden, W R L Anderegg, G Badgley, D Cullenward, J A Abatzoglou, J A Hicke, A T Trugman, J Freeman, J Hamman (2020) "Risks to forest carbon in a changing climate" CarbonPlan https://carbonplan.org/research/forest-risks-explainer
[26] *Climate TRACE*. RMI. (2021, September 17). Retrieved from https://rmi.org/our-work/climate-intelligence/oil-gas-solutions-initiative/climate-trace/.
[27] Zrebiec, A. (2021, September 17). *Johns Hopkins APL Scientists contribute award-winning breakthrough to Ai-Driven climate initiative*. The Applied Physics Laboratory. Retrieved from https://www.jhuapl.edu/PressRelease/210917-apl-climate-trace-team-wins-award.
[28] St. John, J. (2020, July 15). *Climate TRACE: Using satellites and machine learning to pinpoint global emissions*. Energy. Retrieved from https://www.greentechmedia.com/articles/read/climatetrace-using-satellites-and-machine-learning-to-track-global-greenhouse-gas-emissions.
[29] Hammer, D. (n.d.). Dan Hammer. Retrieved from https://www.danham.me/r/.
[30] Worland, J. (2020, July 16). *Al Gore's new project, 'climate trace,' will track emissions*. Science Climate Change. Retrieved from https://time.com/5866881/al-gore-climate-trace-emissions/.

members sparked the goal to track and model global power plant emissions from space. Today, Climate TRACE receives funding from the Benificus Foundation, Google.org, Al Gore, Schmidt Futures, and the partners of Generation Investment Management.

Cloud to Street

"I think satellite and Earth observations can be transformative in how we think about building resilience in a world marked by climate change." -Beth Tellman qtd. By Fischer, 2021

Mission:	To ensure that all vulnerable governments finally access the high quality information they need to prepare for and respond to increasing catastrophes
Founded:	2015
Headquarters/Offices:	Brooklyn, New York
Leadership:	Bessie Scwarz, CEO & Co-Founder Dr. Beth Tellman, Chief Science Officer & Co-Founder
Product(s):	Flood Risk, Flood Mapping, Flood Forecasting
Sectors:	Disaster Preparedness & Response, Global Development

Cloud to Street's free Global Flood Database combines 15 years of data on floods across 169 countries to help scientists, governments, and financial institutions better prepare and protect against the risks of flooding. These maps provide high-resolution down to 30 cm and near real-time picture.

Located in downtown Brooklyn, New York, Cloud to Street operates a platform that can monitor 122 million people, which 18 governments and institutions rely on. Their website receives about 2,000 monthly visitors, and the flood-risk information they can quickly and accurately relay has helped relocate over 7,000 people from high risk areas in times of emergency.[31]

Impact: Research recently published as a cover story in *Nature* from Cloud to Street's Beth Tellman shows that worldwide, flooding is the most prevalent environmental hazard, yet risk-estimates have relied on high uncertainty models.[32,33] Cloud to Street's use of daily satellite imagery has improved the

[31] PitchBook. (n.d.). *Cloud to Street company profile: Valuation & investors*. Cloud to Street Overview. Retrieved from https://pitchbook.com/profiles/company/224060-59#investors.
[32] Fischer, E. (2021, September 27). *Research shows more people living in Floodplains*. NASA Earth Observatory. Retrieved from https://earthobservatory.nasa.gov/images/148866/research-shows-more-people-living-in-floodplains.
[33] Nelson, M. (2021, September 13). *Entrepreneurs Recognized for Innovations in Flood Mapping Technology*. ASU News. Retrieved from https://news.asu.edu/20210913-entrepreneurs-recognized-innovations-flood-mapping-technology.

accuracy of flood mapping technology and helped governments and organizations to prevent and reduce flood-related fatalities.[34]

Advantage: Cloud to Street's advancements in flood mapping technology demonstrates the ability to track floods in real time, on-demand, without ground data. It has also been recognized by the WE Empower UN SDG Challenge, which awards female entrepreneurs whose innovations advance UN Sustainable Development Goals.[35]

Data: Cloud to Street uses NASA satellite data as well as country-level census data and historical flood reports from NOAA.[36] These data are used in conjunction with Google Earth Engine and AI to track and predict flood risk.

Domain expertise: CEO Bessie Schwarz co-founded Cloud to Street with Chief Science Officer Dr. Beth Tellman. Both women are passionate about vulnerable communities in the face of climate change. The 20-person team highlights their academic achievements and work with other environmental and private sector organizations such as Google and Microsoft as part of success. Colin Doyle, the Director of Innovation at Cloud to Street, has also worked closely with NASA's Goddard Space Flight Center Hydrological Sciences Laboratory. The Team is further supported by an academic Science Advisory team with a background in water and environment and an Advisory Board which includes the three other co-founders.

Financial support: Cloud to Street's pre-seed funding round raised about $2.4 million.[37] In July 2021, Cloud to Street's seed round raised approximately $6.9 million with financial support from Google, bringing their total funding to about 49.3 million.[38,39]

---

[34] Tellman, B., Sullivan, J.A., Kuhn, C. *et al.* Satellite imaging reveals increased proportion of population exposed to floods. *Nature* 596, 80–86 (2021).

[35] Arizona State University. (2021, February 26). *About WE Empower*. WE Empower UN SDG Challenge. Retrieved from https://sustainability-innovation.asu.edu/we-empower/about/.
[36] Sunkara, V. (2020, September 25). *Machine Learning Should Combat Climate Change*. Medium. Retrieved from https://medium.com/cloud-to-street/machine-learning-should-combat-climate-change-a38dcc2501d5.
[37] *Cloud to Street - Crunchbase Company Profile & Funding*. Crunchbase. (n.d.). Retrieved from https://www.crunchbase.com/organization/cloud-to-street.
[38] *Cloud to Street*. Cloud to Street | DRK Foundation | Supporting passionate, high impact social enterprises. (n.d.). Retrieved from https://www.drkfoundation.org/organization/cloud-to-street/.
[39] Jacobs, J. (2021, August 5). *Our investment in Cloud to Street*. This Week in MCJ (My Climate Journey). Retrieved from https://myclimatejourney.substack.com/p/our-investment-in-cloud-to-street.

FernLeaf Interactive

Mark Wilbert, Chief Resilience Officer noted that Fernleaf's work with Charleston, SC "is the cornerstone for resilience-focused work being performed throughout the City."

Mission:	FernLeaf Interactive delivers climate resilience planning and support in order for communities and companies to make investments for effective resilience and adaptation
Founded:	2014
Headquarters/Offices:	Asheville, North Carolina
Leadership:	Jeff Hicks, CEO
Product(s):	Climate Intelligence, State & Local Government
Sectors:	Climate Resilience

FernLeaf Interactive works in a public-private partnership with UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC) to bolster FernLeaf's software with NEMAC's applied research expertise.[40] Both organizations have the same goal of promoting the capacity of a community, business, or natural environment to withstand, respond to, and recover from a climate-related disruption.[41]

Impact: Climate-related events are becoming more damaging in cities around the United States, especially for vulnerable populations. FernLeaf Interactive serves a large market by providing comprehensive analysis, built upon the NEMAC's climate risk assessment framework, to support community leader's transition their communities from vulnerable to resilient.[42]

Advantage: Few may know federal climate resources as well as FernLeaf's technical team and they are using that expertise to develop strategies for the municipal marketplace. FernLeaf's ability to provide tailored and easily understood strategic climate resilience plans lies with their two-pronged approach: software product AccelAdapt and a team of experts who provide the Climate Resilience Support. FernLeaf's team includes nationally recognized climate resilience experts who provide accessible, data-informed insights and who have worked with NOAA and

[40] Economic Development Coalition for Asheville-Buncombe County and the Asheville Area Chamber of Commerce. (2016, December 22). *Fernleaf Interactive*. Venture Asheville. Retrieved from https://ventureasheville.com/fernleaf-interactive/
[41] *Accelerate Adaptation*. NEMAC-FernLead Collaborative. (2021). Retrieved from https://nemacfernleaf.com/.
[42] FernLeaf Interactive. (2021). *Climate Resilience Planning & Support*. Fernleaf. Retrieved October 14, 2021, from https://fernleaf.us/.

other federal agencies to develop the US Climate Resilience Toolkit: Steps to Resilience.

Data: FernLeaf works closely with NOAA and NOAA's environmental and climate data, including climate maps, climate charts, high-tide flooding information, historical weather data, and historical thresholds of temperature and precipitation. FernLeaf also gathers localized community data such as building codes, local property uses, and local ordinances.

Domain expertise: CEO and co-founder, Jeff Hicks worked on environmental assessment applications for NOAA, NASA, the US Forest Service, and Los Alamos National Laboratory as well as for a global set of companies including Chevron, Dow Chemical, DuPont, Intel, Kodak, and Lockheed Martin. The rest of the small, 12 person FernLeaf team includes other climate resilience experts, software engineers, and GIS specialists as well as Senior Resilience Associate, Jim Fox. Fox is the past Director of UNC Asheville's NEMAC, has 40 years of climate resilience experience and was personally involved with developing the US Climate Resilience Toolkit Steps to Resilience.[43]

Financial support: FernLeaf has won funding through NOAA's Climate Program Office's Communication, Education, and Engagement Division's cooperative agreement award.[44] This award is for organizations who integrate existing tools and methods to improve efficiency and operability.[45]

[43] *U.S. Climate Resilience Toolkit*. U.S. Climate Resilience Toolkit | U.S. Climate Resilience Toolkit. (n.d.). Retrieved from https://toolkit.climate.gov/#steps.
[44] NOAA. (n.d.). *Increasing U.S. communities' and businesses' resilience to extreme events*. Climate Program Office. Retrieved from https://cpo.noaa.gov/Funding-Opportunities/FY2019-Recipients/CEE/PID/7120/TagID/265/TagName/funding.
[45] NOAA. (2021). *Engagement*. Climate Program Office. Retrieved from https://cpo.noaa.gov/Meet-the-Divisions/Communication-Education-and-Engagement/Engagement.

First Street Foundation

"Millions of Americans think they're safe from flood waters: They aren't."
-Rice & Tebor, 2021

Mission:	To make climate risk accessible, easy to understand and actionable for individuals, governments, and industry
Founded:	2016
Headquarters/Offices:	Brooklyn, New York
Leadership:	Matthew Eby, Executive Director
Product(s):	Climate Services, Climate Risk Flood Resilience
Sectors:	Climate Intelligence, Real Estate

First Street Foundation provides flood risk information services through their platform Flood Factor and is currently expanding its portfolio of climate hazards by developing wildfire risk analysis.[46,47]

Based out of Brooklyn, New York, Flood Factor provides free information on 142 Million properties on their website while also selling bulk data to the real estate sector.[48] Flood Factor has partnered with Realtor.com to provide flood risk data on home listings, expanding Flood Factor's users to include realtor.com's 100 million website users a month.[49]

Impact: Since 1980, floods have cost Americans more than $1 trillion dollars, making flooding the most expensive natural disaster in the United States.[50] Households and property owners need to understand how environmental risk could affect them personally, and First Street Foundation is working to correct information asymmetry by making flood (and soon wildfire) risk information available to all.[51]

---

[46] FirstStreet.org. (2021, August 7). *The fastest growing economic climate risk - wildfire*. Article. Retrieved from https://firststreet.org/research-lab/published-research/fastest-growing-economic-climate-risk-wildfire/.
[47] Lopes, M. (2021, August 9). *First Street partners with Pyregence Consortium to build first property specific, Climate adjusted fire risk model*. Press Release. Retrieved from https://firststreet.org/press/press-release-2021-pyregence-partnership/.
[48] Coalition, A. F. (n.d.). *AFC's Perspective on First Street Foundation's Flood Factor Launch*. AFC Blog. Retrieved from https://floodcoalition.org/2020/06/afcs-perspective-on-first-street-foundations-flood-factor-launch/.
[49] National Association of Realtors. (2020, October 29). *Flood factor™ FAQ*. www.nar.realtor. Retrieved from https://www.nar.realtor/national-flood-insurance-program/flood-factor-faq.
[50] https://www.usatoday.com/story/news/nation/2021/10/11/infrastructure-risk-flooding-first-street-foundation-report/6050243001/.
[51] Olick, D. (2020, August 27). *Every American home is getting a flood-risk score – and many are at higher risk than previously known*. CNBC. Retrieved from https://www.cnbc.com/2020/08/26/every-us-home-gets-flood-risk-score-and-many-are-at-higher-risk.html.

Advantage: First Street Foundations' accurate, free, and property-level information is considered more comprehensive than current government flood risk assessments and was recently commended by NOAA Administrator Richard Spinrad.[52] The data is used by over 180 of the world's top academic researchers who have partnered with First Street Foundation Research Lab to analyze climate perils on infrastructure, market inefficiencies, and vulnerable communities on behalf of government, industry, and 42 top academic institutions such as Harvard, Johns Hopkins, and MIT.

Data: The Foundation uses FEMA flood zone information, a location's history, geographic information, weather prediction, and environmental changes (carbon emission scenarios) to calculate their high-resolution flood maps. Additional data comes from United States Army Corps of Engineers (historical flood data), US Forest Service (wildfire information) and FEMA insurance claims as well as NOAA and NASA weather data from EO systems.

Domain expertise: First Street Foundation's Executive Director and Founder, Matthew Eby, is a recognized marketing expert. The First Street Foundation Team, full of data scientists, software engineers, and research analysts are supported by partner researchers and scientists who specifically work with the flood and wildfire models.[53] The Foundation has a close relationship with NOAA: former NOAA and DOC Chief Data Officer, Ed Kearns, is now First Street's Chief Data Officer.

Financial support: As a 501(c)(3) nonprofit and research organization, First Street Foundation began with grants and large donations. Funders include the Grantham Foundation, the Hightide Foundation, and the 2040 Foundation as well as the Schwab Charitable Fund. Besides these funders, First Street Foundation's application programming interface is available for other companies to purchase.

---

[52] Advancing Earth System Science and Stewardship at NOAA. 116th Cong. (2021)(testimony of Richard W. Spinrad).

[53] Grinapol, C. (2021, March 15). *Matthew Eby: Providing vision and direction for a comprehensive flood model*. Engineering NewsRecord RSS. Retrieved from https://www.enr.com/articles/51047-matthew-eby-providing-vision-and-direction-for-a-comprehensive-flood-model.

Impact Observatory

"[Impact Observatory's AI approach] brings in a whole new dimension to land cover mapping." -Breyer qtd. By Amos, 2021

Mission:	To empower global decision-makers to be planetary superheroes, with the timely, actionable, science-based insights they need to succeed
Founded:	2020
Headquarters/Offices:	Washington D.C. and Santa Fe, New Mexico
Leadership:	Steven P. Brumby, CEO/CTO & Co-Founder Sam Hyde, Co-Founder
Product(s):	Land Use & Land Cover Maps, Carbon Mapping
Sectors:	Global Development, Environmental Intelligence

Impact Observatory offers land use and land cover maps, carbon mapping, and additional data layer maps to monitor biodiversity and human development impact.

Impact Observatory's tools are provided for government use, such as reporting for the UN Sustainable Development goals, NGO and civil society monitoring, and corporate sustainability and ESG analysis. Impact Observatory is partnered with notable organizations such as the United Nations Development Programme, Esri, the National Geographic Society, Microsoft AI for Earth, and the Gordon and Betty Moore Foundation. The partnership with Esri and use of ArcGIS allows for 10 million users to access these maps.[54]

Impact: Biodiversity loss is intertwined with the causes and effects of climate change and the COVID-19 pandemic. Land cover maps are necessary in providing transparency and information for decision-makers to improve solution development such as conservation planning, resource management, the streamlining of monitoring, reporting and verification, and climate change mitigation. Impact Observatory provides this critical, on-demand, tool for broad use.

Advantage: Partnerships with Esri and Microsoft AI as well as unique machine-learning techniques Impact Observatory uses allow for computers to "see" land use patterns that have been inaccessible before.[55] These techniques allow for the map

[54] Esri. (n.d.). *Impact Observatory Overview*. Esri Partner. Retrieved from https://www.esri.com/partners/impact-observatory-a2T5x0000084pJXEAY.
[55] Pruchniewski, J. A. (2021, June 24). *Esri releases new 2020 global land cover map*. Retrieved from https://www.businesswire.com/news/home/20210624005176/en/Esri-Releases-New-2020-Global-Land-Cover-Map.

to be quickly updated every week, detailed, accurate, and consistent.[56] The detail of the maps go to the 10-m resolution, the highest resolution global map to ever be publicly released.[57]

Data: Impact Observatory relies on open-source data from European Space Agency's Copernicus Sentinel-2 satellite imagery in conjunction with an artificial intelligence learning model. Human-labeled pixels and observations are applied to over 400,000 images using machine-learning algorithms to produce an accessible map.

Domain expertise: Impact Observatory was co-founded by Steve Brumby, Sam Hyde, and John Barabino. Steve Brumby has deep domain expertise after working at the Los Alamos National Laboratory, National Geographic Society, and co-founding Descartes Labs. Currently, Brumby serves on the Department of Interior's National Geospatial Advisory Council's Landsat Advisory Group. Sam Hyde provided strategic guidance to the White House when she was Executive Secretariat at the US Global Change Research Program. Other members on Impact Observatory's teams have backgrounds in data science, software engineering, machine learning, science communications, and strategic planning.

Financial support: Impact Observatory has received pre-series A funding in the range of $500,000 to $1 million but has not disclosed investors.[58]

[56] Kontgis, C. (2021, June 25). *Mapping the world in unprecedented detail*. Retrieved from https://caitlin-kontgis.medium.com/mapping-the-world-in-unprecedented-detail-7c0513205b90.
[57] Esri. (2021, June 24). *A new land cover map of the world*. ArcGIS StoryMaps. Retrieved from https://storymaps.arcgis.com/stories/486cd2ae2016454f951c97f802f125b3.
[58] TripleByte. (n.d.). *Impact Observatory*. Software Engineering Jobs. Retrieved from https://triplebyte.com/company/public/impact-observatory.

Jupiter Intelligence

"We believe that climate risk management will be a major industry and… We're confident that we offer the most complete and powerful tools and services in this space" Rich Sorkin qtd by Freedman, 2021

Mission:	Making our world more resilient against the present and future dangers of climate change
Founded:	2017
Headquarters/Offices:	Silicon Valley; Boulder, Colorado; New York City, New York
Leadership:	Rich Sorkin, CEO & Co-Founder Eric Wun, COO & Co-Founder
Product(s):	Climate Services, Climate Analytics, Supply Chain Transparency
Sectors:	Transportation

Jupiter Intelligence uses high resolution, scenario-based physical climate risk projections to provide risk management and resiliency planning to their customers. Jupiter serves private and public sectors, with customers in the US government and at least one of the world's five largest firms in asset management, banking, chemicals, insurance, minerals and mining, oil and gas, pharmaceuticals, power, and reinsurance. Notable users include NASA, the Department of Housing, Liberty Mutual, and BP.

Impact: Climate related risks are becoming more prevalent and having more of an economic impact, including across sectors such as insurance, banking, asset management, real estate, energy, manufacturing, retail, agriculture, public sectors, and NGOs. Jupiter repackages satellite data to provide predictive analytics that identify, mitigate, and manage these climate-related risks.

Advantage: Jupiter's advantage is that they have not only been early to the party, but their entrepreneurial approach to addressing climate risk as a business is coupled with numerous leaders in their field. As described by Jason Samenow of *The Washington Post* in February 2018, "the weather and climate risk industry has not seen a company enter the space with this mix of financial backing, technology, and intellectual heft in years, if ever."[59]

[59] Deaton, J. (2021, May 27). *Business booms at climate risk start-up as threat from extreme weather grows*. The Washington Post. Retrieved from https://www.washingtonpost.com/weather/2021/05/27/jupiter-intel-climate-risk-business/.

Data: Jupiter Intelligence uses numerous government models and analytics, including the CESM® global climate model sponsored by the National Science Foundation and the US Department of Energy as well as the combination of NOAA weather data, land use data, and other environmental information.

Domain expertise: CEO and co-founder Rick Sorkin has recruited a 58-member team from research laboratories and corporations with knowledge on product development, business, Earth and climate science, AI, big data management, and includes recognized experts and Nobel Prize Laureate. Jupiter Intelligence attributes their deep domain expertise in their team, advisors, and leadership to its success. Pat Harr, Senior Weather Analyst and Science Fellow previously served as Atmospheric Section Head at the National Science Foundation. Advisors include Deputy Undersecretary of Defense, Sherri Goodman and United States' Special Envoy for Climate Change, Todd Stern as well as others with domain expertise from US agencies, including NOAA, NCAR, NSF, NASA, the CIA, the Department of the Treasury and the Department of State.

Financial support: Early financing from strategic partners and investors raised $10 million, followed by an additional $30 million from venture firms and high net worth individuals, including Liberty Mutual, SYSTEMIQ, DCVC, QBE Ventures, Energize Ventures, Ignition Partners, and MS&AD Ventures.[60,61] In October 2021, Clearvision Ventures and MPower Partners co-led Jupiter's established investment partners and CDPQ in a $54 million Series C Financing round, significantly more than total investments used to build Jupiter.[62]

[60] Freedman, A. (2021, September 14). *Climate risk firm Jupiter Intel picks up major investor to jump-start an Asian expansion*. Energy & Environment. Retrieved from https://www.axios.com/climate-risk-jupiter-intel-mpower-partners-investment-513558ea-6dac-4317-af21-9c0a1b29fcbd.html.
[61] *Jupiter Intelligence Company Information, funding & investors*. Dealroom.co. (n.d.). Retrieved from https://app.dealroom.co/companies/jupiter_intelligence.
[62] Jupiter. (2021, October 21). *Jupiter announces $54 million in new funding*. GlobeNewswire News Room. Retrieved from https://www.globenewswire.com/news-release/2021/10/21/2318408/0/en/Jupiter-Announces-54-Million-in-New-Funding.html.

Orbital Insight

"Enterprises and government agencies make big decisions without a clear picture of what's happening in both their own operations as well as external networks of business and societal connections"-Kevin O'Brien, Orbital Insight's CEO

Mission:	Creating a real-time information stream for water resource planners, engineers, financial analysts, utility managers, and consumers
Founded:	2013
Headquarters/Offices:	Palo Alto, California
Leadership:	James Crawford, Founder, Chairman, & CTO; Kevin O'Brien, CEO
Product(s):	Geospatial Data Analytics, AI, Supply Chain Transparency
Sectors:	Defense, Transportation, Supply Chain, Broad Geospatial Analytics

Orbital Insight is recognized by many as an industry leader in integrating EO data sources to produce intelligence for everything from supply chain, real estate, financial services, consumer goods, energy and defense.[63] Whether aerial, drone, satellite, IoT, SAR, AIS, to connected cars, Orbital Insight provides large-scale data integration and analytics for government and private sector clients as recently featured in a *Defense One* article examining Russian activities in Crimea.[64]

Orbital Insight applies extensive civil and defense domain expertise to a host of industry clients such as Unilever, Chevron, The World Bank, and Standard & Poor's. In August 2021, it launched a global supply chain capability harnessing AI to improve visibility and identify potential disruptions.[65] Their GO Platform is the centerpiece of their capabilities and automatically collects new data allowing users to evaluate trends and notice significant changes.[66] In their words: Orbital Insight

[63] AUTHORITY. (2021, August 19). *Orbital Insight Launches Supply Chain Intelligence Solution*. AIT News Desk. Retrieved from https://aithority.com/technology/analytics/orbital-insight-launches-supply-chain-intelligence-solution-to-create-end-to-end-supply-chain-visibility-and-illuminate-risk-using-ai/.
[64] Tucker, P. (2021, September 2). *Was Russia's April exercise a practice run for a Ukraine invasion?* Science & Tech. Retrieved from https://www.defenseone.com/technology/2021/09/russias-april-exercise-crimea-may-have-been-ukraine-invasion-practice-run/185082/.
[65] Rist, K. (2021, September 6). *How Geospatial Intelligence Startups are Transforming B2B Sectors*. Forbes. Retrieved from https://www.forbes.com/sites/kjartanrist/2021/09/06/how-geospatial-intelligence-startups-are-transforming-b2b-sectors/?sh=4b8753c92353.
[66] Orbital Insight. (n.d.). *Geospatial Technology Platform*. Platform: Orbital Insight GO. Retrieved from https://orbitalinsight.com/geospatial-technology.

helps organizations understand truths about an increasingly interconnected world.[67]

Impact: The application of Orbital Insight's capabilities is extensive and reaches numerous sectors-from traditional customers in the defense area to private sector customers in retail. With growing concern over global supply chain disruption as a result of the COVID-19 pandemic, their newly-launched intelligence capability comes to the market at a critical time.

Advantage: A key advantage is their strong reputation as an industry leader and proven experience in crunching raw geospatial data combined with AI and machine learning to analyze trends at scale.

Data: Although they are a major consumer of commercial sources such as Planet and Airbus, Orbital Insight also uses freely-available sources such as Landsat data. Many of its algorithms and other analytic capabilities originated in the civil and defense sectors.

Domain expertise: Founder James Crawford, is a leader in software research and development with over two decades of computer science expertise, including time at NASA. The more than 200-person staff includes data scientists as well as former defense and geospatial analysts.

Financial support: In addition to a well-established list of defense, civil, and private sector clients, per *Crunchbase*, Orbital Insight has raised more than $128.7 million in six rounds of financing led by Sequoia Capital and Google Venture and Goldman Sachs. It was recognized as one of Forbes' Next Billion-Dollar Startups in 2017.[68]

[67] Orbital Insight. (2021, August 18). *Orbital Insight Launches Supply Chain Intelligence solution to create end-to-end supply chain visibility and illuminate risk using AI*. https://www.prnewswire.com/news-releases/orbital-insight-launches-supply-chain-intelligence-solution-to-create-end-to-end-supply-chain-visibility-and-illuminate-risk-using-ai-301358035.html.
[68] *Invest or sell Orbital Insight Stock*. Forge Global. (n.d.). Retrieved from https://forgeglobal.com/orbital-insight_stock/.

Pachama

"Pachama makes it easier for any company to become carbon neutral"
- Carmichael Roberts

Mission:	To restore nature to solve climate change
Founded:	2018
Headquarters/Offices:	San Francisco, California
Leadership:	Diego Saez Gil, CEO & Founder
Product(s):	Reforestation, Carbon Credit Marketplace, Nature-Based Solutions
Sectors:	Agriculture Forestry, Conservation

Pachama applies AI and satellite imagery to the forest carbon credit market. They work to leverage "data, artificial intelligence, and automation to protect ecosystems, restore forests, and improve carbon markets."

Forests are an effective tool of carbon removal and a crucial component of the carbon credit market. Measuring carbon storage of a forest for the purpose of carbon crediting has historically been difficult to verify because it is a manual and labor-intensive process with little transparency. Manual verification involves physically entering the forest to count and monitor trees, which means data becomes quickly outdated.[69] Pachama uses LiDAR satellite data, AI, and machine learning to monitor and predict the amount of carbon in a forest with up to 90% accuracy. Pachama's process validates carbon sequestration of forest restoration projects which encourages and scales the market for buying and selling carbon credits.

Pachama's online marketplace to buy carbon credits, carbon sequestration validation, and reforestation projects have led to partnerships with Microsoft, Shopify, and Mercado Libre, one of the largest e-commerce and financial services companies from Latin America.[70]

---

[69] Peters, A. (2021, March 9). *How AI Startup Pachama Brings Transparency to Carbon Offset Projects*. Most Innovative Companies. Retrieved from https://www.fastcompany.com/90600400/pachama-most-innovative-companies-2021.

[70] Shieber, J. (2021, March 9). *Mercado libre taps Pachama to monitor and manage its $8 million investment in Latin American rainforest restoration*. TechCrunch. Retrieved from

Impact: By monitoring reforestation projects for carbon emissions offsets, Pachama's technology encourages forest restoration and the carbon credit market. Estimates suggest that the market for carbon offsets could be worth $100 billion by the end of the decade.[71,72] Not only is Pachama's work relevant for companies purchasing credits, but governments addressing climate change as well. The Biden Administration included carbon capture as part of 2030 Greenhouse Gas Pollution Reduction Target,[73] and a recent pledge at COP 26 designated $19 Billion in private and public funds to accelerate the reforestation of forests.[74]

Advantage: Pachama's use of satellite imagery and AI tech to improve global forest carbon markets earned them recognition as one of the World Economic Forum's Technology Pioneers.[75] Their ability to rid the market of inefficiencies by providing transparency and verifying that carbon credits are actually linked to a reduction in carbon emissions is what makes them so exceptional.[76] Companies are willing to fund forestry preservation and restoration by purchasing carbon offsets and Pachama's use of satellite imagery makes the process easy, accessible, and transparent- effectively encouraging the forest carbon credit market.[77,78]

Data: LiDAR imaging and other high resolution imaging satellite data feeds Pachama's AI and machine learning algorithms. The satellite models are then used in conjunction with radar data to monitor 40 forests worldwide.

---

https://techcrunch.com/2021/03/09/mercado-libre-taps-pachama-to-monitor-and-manage-its-8-million-investment-in-latin-american-rainforest-restoration/.

[71] Farley, A. (2021, July 27). *This startup ensures that forestry-based carbon offsets deliver on their promises*. Most Innovative Companies. Retrieved from https://www.fastcompany.com/90658983/this-startup-makes-sure-that-forestry-based-carbon-offsets-deliver-on-their-promises.
[72] Kobayashi-Solomon, E. (2020, October 28). *The Smart Money is Investing in Carbon Credits*. Sustainability. Retrieved from https://www.forbes.com/sites/erikkobayashisolomon/2020/10/28/the-smart-money-is-investing-in-carbon-credits/?sh=2afd554227e7.
[73] Wolfrom, J. (2021, September 22). *Local startups remove carbon from the atmosphere-but is it an effective approach?* News/Newsletter/The City. Retrieved from https://www.sfexaminer.com/news/local-startups-remove-carbon-from-the-atmosphere-but-is-it-an-effective-approach/.
[74] Neuman, S. (2021, November 2). *Nations with 85% of Earth's forests pledge to reverse deforestation*. Special Series: The COP26 summit. Retrieved from https://www.npr.org/2021/11/02/1051390697/deforestation-forest-deal-cop25-amazon-brazil.
[75] GlobeNewswire News Room. (2021, June 15). *Pachama awarded as Technology Pioneer by World Economic Forum*. Pachama selected as most promising Technology Pioneer of 2021. Retrieved from https://www.globenewswire.com/en/news-release/2021/06/15/2246985/0/en/Pachama-Awarded-as-Technology-Pioneer-by-World-Economic-Forum.html.
[76] Fortune Editors. (2021, October 25). *Pachama: 2021 Impact 20*. Fortune. Retrieved from https://fortune.com/impact20/2021/pachama/.
[77] Shieber, J. (2021, April 30). *As concerns rise over forest carbon offsets, Pachama's verified offset marketplace gets $15 million*. TechCrunch. Retrieved from https://techcrunch.com/2021/04/30/as-concerns-rise-over-forest-carbon-offsets-pachamas-verified-offset-marketplace-gets-15-million/.
[78] Jacobs, J. (2021, May 4). *Our investment in Pachama*. This Week in MCJ (My Climate Journey). Retrieved from https://myclimatejourney.substack.com/p/our-investment-in-pachama.

Domain Expertise: CEO and Pachama Founder Diego Saez Gil has a strong history as an technology entrepreneur. Pachama's team boasts members with strong backgrounds in software and data science who previously worked with Google, SpaceX, Orbital Insight, Facebook, and Microsoft. Their advisory board includes the former Director of Sustainability at Microsoft, Joan Maloof, the Founder of the Old-Growth Forest Network and Scott Harrison, Founder of charity:water.

Support: Financial investment has been provided by Saltwater, Y Combinator, Bill Gates' Investment firm Breakthrough Energy Ventures, Amazon, Social Capital, and Lowercarbon Capital.[79,80] In total, Pachama has been awarded $24 million through investments and has an $8 million contract with Mercado Libre.[81]

[79] Saez Gil, D. (2020, September 17). *Pachama welcomes amazing new investors to Support Our Mission*. Medium. Retrieved from https://pachamainc.medium.com/pachama-welcomes-amazing-new-investors-to-support-our-mission-a712224b2e1c.
[80] i3 Connect. (n.d.). *Pachama: Investment rounds, top customers, partners and investors* . i3 Connect. Retrieved from https://i3connect.com/company/pachama.
[81] Shieber, J. (2021, March 9). *Mercado libre taps Pachama to monitor and manage its $8 million investment in Latin American rainforest restoration*. TechCrunch. Retrieved from https://techcrunch.com/2021/03/09/mercado-libre-taps-pachama-to-monitor-and-manage-its-8-million-investment-in-latin-american-rainforest-restoration/.

The Climate Service

"[We've] been scaling to prepare for this very moment."
-James McMahon qtd. by Allam, 2021

Mission:	To embed climate risk data into every decision on the planet, and facilitate the world's transition to a lower carbon economy
Founded:	2017
Headquarters/Offices:	Durham, North Carolina
Leadership:	James McMahon, CEO & Founder
Product(s):	Climate Risk Analytics
Sectors:	Finance & Insurance

The Climate Service (TCS) is a climate risk data and analysis technology firm which started as part of Asheville's Collider initiative. Through Climanomics-a software platform that puts a price on climate risk to enable analysis-TCS serves corporations, financial institutions, real estate investors, communities, and the US Government.[82]

Impact: As recently stated in a recent Bloomberg Law article, interest in financial reporting is "the latest sign that climate change is altering the way in which investors measure value, as a hotter planet promises to reshape fortunes in the corporate world." Former SEC Chair the head of the Task Force on Climate-related Financial Disclosures (TCFD), Mary Schapiro, remarked that demand for climate reporting is "at an all time high" and getting "more intense and sophisticated."[83] Japan's Financial Services Agency has already committed large Japanese companies to report climate-related disclosures, which will affect almost 4,000 companies.[84] TCS provides companies with a solution to quantify climate risk in financial terms.

Advantage: In addition to a partnership with IBM and reach of global real estate investment firm, Nuveen, TCS added more credibility to their brand when it was recently recognized as the Climate Risk Advisory Firm of the Year as part of the Energy Risk Awards 2021.

---

[82] The Climate Service. (n.d.). *The Climate Service*. Know Your Climate Risk. Retrieved from https://www.theclimateservice.com/.
[83] Marsh, A. (2021, October 14). *Ex-SEC head says climate disclosure support has 'skyrocketed'*. news.bloomberglaw.com. Retrieved from https://news.bloomberglaw.com/securities-law/ex-sec-head-says-climate-disclosure-support-has-skyrocketed.
[84] Nikkei Staff Writers. (2021, October 5). *Japan to require 4,000 companies to disclose climate risks*. Climate Change. Retrieved from https://asia.nikkei.com/Spotlight/Environment/Climate-Change/Japan-to-require-4-000-companies-to-disclose-climate-risks.

Data: The Climate Service relies on climate and socioeconomic data from IPCC, NASA, NOAA, and other public academic and commercial sources. The organization merges this data with peer-reviewed climate model projections and customer asset data to deliver climate risk analysis consistent with pricing of climate risk developed by the Task Force on Climate-related Financial Disclosures.

Domain expertise: CEO and Founder, James McMahon leads a strong leadership team of respected professionals with ties NOAA, NASA, the US Army, and private organizations such as Morgan Stanley.[85] McMahon spent six years as the Senior Advisor to the Director of NOAA's National Centers for Environmental Information (NCEI) and was The Collider's CEO. Their Advisory Board includes four IPCC Nobel Prize winning scientists including Dr. Tom Karl, who served as Director of NOAA's NCEI and Chair of the US Global Change Research Program.

Financial support: The Climate Service got its start with a traditional mix of venture investment firms and angel investors. In April 2020, The Climate Service ended their Series A funding round with 3.82 million.[86] Persei Venture LLC led the most recent investment round which Synovia Capital (who focuses on ecosystem management in the data analytics sector) and the Association of International Certified Professional Accountants joined. TCS also has financial support from MBP Climate LLC and Wells Fargo Startup Accelerator, LLC.[87,88]

[85] Allam, C. (2021, June 28). *This North Carolina CleanTech startup is helping the business world get to net-zero*. Companies B2B. Retrieved from https://hypepotamus.com/feature/the-climate-service-north-carolina/.
[86] Shieber, J. (2020, April 14). *North Carolina-based The Climate Service raises $3.8 million for climate audits*. TechCrunch. Retrieved from https://techcrunch.com/2020/04/14/north-carolina-based-the-climate-service-raises-3-8-million-for-climate-audits/.
[87] Hogan, J. (2020, April 14). *The Climate Service secures $3.825M series A financing round led by Persei Venture*. The Climate Service Secures $3.825m Series A Financing Round Led by Persei Venture. Retrieved from https://www.prnewswire.com/news-releases/the-climate-service-secures-3-825m-series-a-financing-round-led-by-persei-venture-301039710.html
[88] *The Climate Service - funding, financials, valuation & investors*. Crunchbase. (n.d.). Retrieved from https://www.crunchbase.com/organization/the-climate-service/company_financials.

Tomorrow.io

"Our users don't have to play the role of meteorologists"
-Dan Stillman, Director of Marketing, Space, and Government, Tomorrow.io

Mission:	To help people and organizations manage weather related challenges with the best information and insights
Founded:	2016
Headquarters/Offices:	Boston, Massachusetts
Leadership:	Shimon Elkabetz, CEO & Co-Founder Itai Zlotnik, CCO, Co-Founder Rei Gogger, CSO & Co-Founder
Product(s):	Weater and Climate Security Intelligence Platform and Weather by Tomorrow App
Sectors:	Weather & Climate Intelligence

Tomorrow.io's (formerly ClimaCell) creates weather and climate intelligence from primarily government data sources.[89] Offering a customizable Weather Intelligence Platform, Tomorrow.io serves over 1,000 businesses including Ford, United, and Delta. It's Weather by Tomorrow App also has a wide reach with approximately 27,400 reviews on the Apple App Store and a 4.7 out of 5.00 rating. In November, 2021 Tomorrow.io further expanded their products to offer a weather and climate security platform software. Their new addition combines weather and environmental parameters, modeling, a flood index, climate risk, and recommended actionable insights which will allow users to make educated decisions.[90]

The United States Air Force awarded Tomorrow.io with a $20 million contract to launch 32 satellites with radar capabilities.[91] These new satellites will provide precipitation data in areas of US military interest where there are no functioning weather systems on the ground, revolutionizing operational forecasting and accuracy. In December 2021, Tomorrow.io announced plans to go public with a merger through special purpose acquisition company (SPAC) Pine Technology

[89] *Welcome to Tomorrow.io*. Tomorrowio. (n.d.). Retrieved from https://www.tomorrow.io/company/.
[90] Stillman, D. (2021, November 16). *Tomorrow.io unveils global weather and climate security platform*. Tomorrow.io Post. Retrieved from https://www.tomorrow.io/blog/tomorrow-io-unveils-global-weather-and-climate-security-platform/.
[91] Werner, D. (2021, October 1). *Tomorrow.io wins Air Force funding for weather satellite constellation*. Retrieved from https://spacenews.com/tomrorow-io-wins-air-force-contract/.

Acquisition Corp. Proceeds from the deal are being directed towards the platform and the satellite launch.[92]

Impact: Most businesses are impacted by weather (70%) and yet don't understand what weather data means for them (90%). CEOs note that weather impact and volatility is usually a top 5 concern for them. Tomorrow.io delivers weather and climate intelligence-translating weather data into actionable insights and improving decision-making.

Advantage: Tomorrow.io transforms weather data into a predictive insights dashboard and platform that can be customized to each industry, *showing* their clients how weather will impact business. Additionally, Tomorrow.io's investment into launching their own satellite constellation will change operational weather forecasting not only by expanding global coverage but improving revisit time from daily to hourly and by providing insights for an estimated five billion people that live outside current ground-based radar coverage.

Data: Products rely on the aggregate of weather prediction models from NOAA. Validation (weather verification) from NASA, NOAA, and NOAA's automated weather observation system (AWOS) or surface observation station (ASOS) networks.

Domain Expertise: Led by CEO and Co-Founder, Shimon Elkabetz, Tomorrow.io has assembled a well-known prestigious group of advisors including Kathryn Sullivan, PhD, former NOAA Administrator and NASA astronaut; Rear Admiral Tim Gallaudet, PhD (Retired) former NOAA Deputy Administrator; Marshall Shepherd, PhD, Director, UGA Atmospheric Sciences Program; and Keith Masback, former Executive Director, USGIF, is also an advisor.

Financial Support: With recent Series D funding of $77 million, it is estimated that Tomorrow.io has received more than $185 million as featured in numerous publications such as TechCrunch, Axios, and SpaceNews.[93,94,95,96]

---

[92] Nishant, N. (2021, December 7). *Weather security platform tomorrow.io to go public via $1.2 bln Spac deal*. U.S. Markets. Retrieved from https://www.reuters.com/markets/us/weather-security-platform-tomorrowio-go-public-via-12-bln-spac-deal-2021-12-07/

[93] *Tomorrow.io - funding, financials, valuation & investors*. Crunchbase. (n.d.). Retrieved from https://www.crunchbase.com/organization/climacell/company_financials.

[94] Lardinois, F. (2021, March 30). *Weather Platform ClimaCell is now Tomorrow.io and Raises $77M*. TechCrunch. Retrieved from https://techcrunch.com/2021/03/30/weather-platform-climacell-is-now-tomorrow-io-and-raises-77m/.

[95] Freedman, A. (2021, September 9). *After Hurricane Ida, Flood Forecast System unveiled via Tomorrow.io*. Energy & Environment. Retrieved from https://www.axios.com/after-hurricane-ida-flood-forecasting-tomorrowio-3ee53579-4d13-41a9-9240-2b3f17713981.html.

[96] Fisher, K. (2021, October 1). *US inks $20 million deal to launch high-tech weather satellites in Space*. CNN. Retrieved from https://www.cnn.com/2021/09/30/world/us-weather-satellite-deal-scn/index.html.

True Elements

What True Elements has done for water quality data was never before possible. It's nothing short of a game changer." -Bob Bowcock, Managing Director, Aqua Capital Management

Mission:	Creating a real-time information stream for water resource planners, engineers, financial analysts, utility managers, and consumers
Founded:	2019
Headquarters/Offices:	Naples, Florida
Leadership:	Kim Patrick Kobza, CEO
Product(s):	Water Quality Forecasting
Sectors:	Water

True Elements is a water quality forecasting platform with the goal of making water quality simple with TrueQI- water quality indexing system for government agencies, NGOs and corporations who have ESG guidelines and ESG Focused Investment Funds in addition to industrial and commercial water users.[97] True Elements is a member of the Global Water Council and won a Global Water Award in 2021 which recognizes companies transforming the water industry.[98]

Impact: As noted in a 2019 World Bank report, "the world faces an invisible crisis of water quality. Its impacts are wider, deeper, and more uncertain than previously thought and require urgent attention."[99] Therefore, an urgent need exists for complete and comprehensive water quality information. Many organizations are "data rich but information poor," suggesting that although they have data, there is no knowledge attached to it.[100] True Elements offers one, simple-to-use platform and the technical infrastructure and visualization features to provides forecasted water quality data which improves water management and stewardship. The information provided can also improves efficiency of the manufacturing process, avoid infrastructure failure, and minimize health risks.

---

[97] True Elements. (2021, October 6). *Water Quality Data & Forecasting*. Home: True Elements. Retrieved from https://trueelements.com/.
[98] True Elements. (2021, May 13). *True Elements Joins the Global Water Council*. Newsfeed. Retrieved from https://trueelements.com/newsfeed/true-elements-joins-the-global-water-council/.
[99] World Bank. (2019, August 20). *Quality Unknown: The Invisible Water Crisis*. Feature Story. Retrieved from https://www.worldbank.org/en/news/feature/2019/08/20/quality-unknown.
[100] Sarni, W. (2021, April 22). *Tech and Innovation Offer Promise for the World's Most Water-Challenged Regions*. Editorial Events. Retrieved from https://techonomy.com/2021/04/investment-in-technology-and-innovation-offers-promise-for-the-worlds-most-water-challenged-regions/.

Advantage: True Element's AI technology is becoming the standard in water quality forecasting due to its ability to incorporate and standardize data, infer missing data, learn and adjust from experience, and use historical, and environmental factors to predict water quality up to 14 days in advance.[101] True Elements monitors for approximately 400 contaminants and considers the impact of weather, chemical discharge, and other watershed events to provide organizations with comprehensive information- not just fragmented data that they've dealt with before.

Data: True Elements' AI pulls publicly available water quality data from over 1.5 million sensors and 100's of federal and local databases. Public water quality data is provided by EPA's Water Quality Portal and USGS continuous real-time water quality feature. True Elements also uses pollution discharge permits (NPDES) from the EPA and Hydrologic Unit Codes from USGS.[102,103,104]

Domain expertise: CEO Kim Patrick Kobza, who has years of experience as tech-based company CEO leads a self-described "non-hierarchical" team of experts of water science, management, AI, technology, military intelligence, law, and engineering. Will Sarni, a thought leader on water strategy and Founder and CEO of the Water Foundry, serves as True Element's industry advisor.

Financial support: True Elements began with Angel Investor funding. The last funding round reported $1.38 Million. In June, 2021, True Elements received an additional $1 million dollars from BMNT to advance their technology.[105]

---

[101] True Elements. (2021, June 23). *Colorado River Basin first to benefit from strategic investment in water quality data.* Newsfeed. Retrieved from https://trueelements.com/newsfeed/colorado-river-basin-first-to-benefit-from-strategic-investment-in-water-quality-data/.
[102] USGS. (n.d.). *What is continuous real-time water quality (RTWQ)?* Real-time water quality. Retrieved from https://waterwatch.usgs.gov/wqwatch/faq?faq_id=1.
[103] USGS. (n.d.). *Hydrologic Unit Maps*. USGS Water Resources: About USGS Water Resources. Retrieved from https://water.usgs.gov/GIS/huc.html.
[104] Environmental Protection Agency. (n.d.). *National Pollutant Discharge Elimination System (NPDES)*. NPDES Around the Nation. Retrieved from https://www.epa.gov/npdes.
[105] CB Insights. (n.d.). *True Elements*. True Elements - Headquarter Locations, Competitors, Financials, Employees. Retrieved from https://www.cbinsights.com/company/true-elements.

Appendix B

Accelerate Adaptation. NEMAC-FernLead Collaborative. (2021). Retrieved from https://nemacfernleaf.com/.

Accurate air quality, pollen & active fires information. BreezoMeter. (n.d.). Retrieved from https://www.breezometer.com/.

Advancing Earth System Science and Stewardship at NOAA. 116th Cong. (2021) (testimony of Richard W. Spinrad).

Allam, C. (2021, June 28). *This North Carolina CleanTech startup is helping the business world get to net-zero*. Companies B2B. Retrieved from https://hypepotamus.com/feature/the-climate-service-north-carolina/.

Ambrose, S. (2021, July 6th). Personal Communication.

Arent, D.J., R.S.J. Tol, E. Faust, J.P. Hella, S. Kumar, K.M. Strzepek, F.L. Tóth, and D. Yan, 2014: Key economic sectors and services. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 659-708.

Arizona State University. (2021, February 26). *About WE Empower*. WE Empower UN SDG Challenge. Retrieved from https://sustainability-innovation.asu.edu/we-empower/about/.

Asghar, A., Christensen, C., Di Pippo, S., Holla-Maini, A., Al Husseini, A. M., MacDonald, A., Onoda, M., & Stofan, E. (2021, September). *Global Future Council on Space: Space for Net Zero*. White Paper. Retrieved from https://www3.weforum.org/docs/WEF_Space_and_Net_Zero_2021.pdf.

AUTHORITY. (2021, August 19). *Orbital Insight Launches Supply Chain Intelligence Solution*. AIT News Desk. Retrieved from https://aithority.com/technology/analytics/orbital-insight-launches-supply-chain-intelligence-solution-to-create-end-to-end-supply-chain-visibility-and-illuminate-risk-using-ai/.

Bateman, J. (2021, October 8). *U.S. hit with 18 billion-dollar disasters so far this year*. News & Features. Retrieved from https://www.noaa.gov/news/us-hit-with-18-billion-dollar-disasters-so-far-year.

Bender, B., & Custodio, J. (2021, October 31). *'It is a game changer': Waging War on climate change from space*. Energy & Environment. Retrieved from https://www.politico.com/news/2021/10/31/climate-change-space-satellites-517773.

Bletter, D. (2021, November 1). *How a search for clean air turned into the world's Favorite pollution app*. ISRAEL21c. Retrieved from https://www.israel21c.org/how-a-search-for-clean-air-turned-into-the-worlds-favorite-pollution-app/.

Blue Sky Analytics. (2020, May 1). *Blue Sky Analytics wins MIT Solve & AI Innovations Challenge*. Press Release. Retrieved from https://blueskyhq.in/blog/blue-sky-analytics-wins-mit-solve-ai-innovations-challenge.

Brumby, S. (2021, July 20th). Personal Communication.

Brunsdale, E. (2021, July 30). *Global water crises unleash tsunami of watertech: Climate tech VC*. Climate Tech VC | A weekly newsletter on climate and innovation. https://climatetechvc.org/global-water-crises-unleash-tsunami-of-watertech/.

Business Wire. (2018, September 13). *Breezometer Closes series B fundraising with $7.75M USD*. Retrieved from https://www.businesswire.com/news/home/20180913005402/en/BreezoMeter-Closes-Series-B-Fundraising-with-7.75M-USD.

CB Insights. (n.d.). *True Elements*. True Elements - Headquarter Locations, Competitors, Financials, Employees. Retrieved from https://www.cbinsights.com/company/true-elements.

Chalfant, M. (2021, September 7). *White House asks Congress for $24 billion in disaster relief*. TheHill. https://thehill.com/homenews/administration/571111-white-house-asks-congress-for-24-billions-in-disaster-relief.

The Climate Service - funding, financials, valuation & investors. Crunchbase. (n.d.). Retrieved from https://www.crunchbase.com/organization/the-climate-service/company_financials.

The Climate Service. (n.d.). *The Climate Service*. Know Your Climate Risk. Retrieved from https://www.theclimateservice.com/.

Climate TRACE. RMI. (2021, September 17). Retrieved from https://rmi.org/our-work/climate-intelligence/oil-gas-solutions-initiative/climate-trace/.

Climate TRACE: The Source. (2021, September 16). *Climate TRACE releases first comprehensive, Independent Database of Global Greenhouse Gas Emissions*. Medium. Retrieved from https://medium.com/climate-trace-the-source/climate-trace-releases-first-comprehensive-independent-database-of-global-greenhouse-gas-emissions-718822862862.

Cloud to Street. Cloud to Street | DRK Foundation | Supporting passionate, high impact social enterprises. (n.d.). Retrieved from https://www.drkfoundation.org/organization/cloud-to-street/

Cloud to Street - Crunchbase Company Profile & Funding. Crunchbase. (n.d.). Retrieved from https://www.crunchbase.com/organization/cloud-to-street.

Cloud to street - LinkedIn. (n.d.). Retrieved October 14, 2021, from https://www.linkedin.com/company/cloud-to-street.

Cloud to Street. (n.d.). *Cloud to Street*. Flood Tracking for disasters and insurance. Retrieved from https://www.cloudtostreet.ai/.

Coalition, A. F. (n.d.). *AFC's Perspective on First Street Foundation's Flood Factor Launch*. AFC Blog. Retrieved from https://floodcoalition.org/2020/06/afcs-perspective-on-first-street-foundations-flood-factor-launch/.

Cronin, M. (2016, August 2). *Asheville Companies Create Online Map that tracks Zika in U.S.* The Asheville Citizen Times. Retrieved from https://www.citizen-times.com/story/news/local/2016/08/02/asheville-companies-create-online-map-tracks-zika-us-zika-virus-climate-science-the-collider-asheville-noaa/87922864/.

Deaton, J. (2021, May 27). *Business booms at climate risk start-up as threat from extreme weather grows*. The Washington Post. Retrieved from https://www.washingtonpost.com/weather/2021/05/27/jupiter-intel-climate-risk-business/.

Drenik, G. (2021, September 9). *This Company Is Making Sure People Check Air Quality As Much As They Do Weather*. Forbes. Retrieved from https://www.forbes.com/sites/garydrenik/2021/09/07/this-company-is-making-sure-people-check-air-quality-as-much-as-they-do-weather/?sh=49df1a0f4aeb.

Economic Development Coalition for Asheville-Buncombe County and the Asheville Area Chamber of Commerce. (2016, December 22). *Fernleaf Interactive*. Venture Asheville. Retrieved from https://ventureasheville.com/fernleaf-interactive/.

Elkabetz, D. (2020, January 2). *The top 5 questions we get about Breezometer's air quality data*. BreezoMeter Blog. Retrieved from https://blog.breezometer.com/top-5-questions.

Environmental Protection Agency. (2016, September 29). *Climate Change Impacts by Sector*. Climate Change Impacts. Retrieved from https://19january2017snapshot.epa.gov/climate-impacts/climate-change-impacts-sector_.html.

Environmental Protection Agency. (n.d.). *National Pollutant Discharge Elimination System (NPDES)*. NPDES Around the Nation. Retrieved from https://www.epa.gov/npdes.

Erwin, S. (2021, November 8). *Earth needs a 'mission control' to manage climate data collected from space*. SpaceNews. Retrieved from https://spacenews.com/earth-needs-a-mission-control-to-manage-climate-data-collected-from-space/.

Esri. (2021, June 24). *A new land cover map of the world*. ArcGIS StoryMaps. Retrieved from https://storymaps.arcgis.com/stories/486cd2ae2016454f951c97f802f125b3.

Esri. (n.d.). *Impact Observatory Overview*. Esri Partner. Retrieved from https://www.esri.com/partners/impact-observatory-a2T5x0000084pJXEAY.

European Space Agency. (2021, August 31). *Satellite data provide valuable support For IPCC climate report*. Phys.org. https://phys.org/news/2021-08-satellite-valuable-ipcc-climate.html.

Farley, A. (2021, July 27). *This startup ensures that forestry-based carbon offsets deliver on their promises*. Most Innovative Companies. Retrieved from https://www.fastcompany.com/90658983/this-startup-makes-sure-that-forestry-based-carbon-offsets-deliver-on-their-promises.

FernLeaf Interactive. (2021). *Climate Resilience Planning & Support*. Fernleaf. Retrieved October 14, 2021, from https://fernleaf.us/.

Fiedler, T., & Bush, M. (2021, May 1). *Can Asheville become more than beer and bears?* WFAE 90.7 - Charlotte's NPR News Source. https://www.wfae.org/energy-environment/2021-05-01/can-asheville-become-more-than-beer-and-bears.

Find Your Home's Flood Risk. Flood Factor. (n.d.). Retrieved from https://floodfactor.com/.

FirstStreet.org. (2021, August 7). *The fastest growing economic climate risk - wildfire*. Article. Retrieved from https://firststreet.org/research-lab/published-research/fastest-growing-economic-climate-risk-wildfire/.

Firststreet.org. (n.d.). *Home - First Street Foundation*. FirstStreet. Retrieved from https://firststreet.org/.

Fischer, E. (2021, September 27). *Research shows more people living in Floodplains*. NASA Earth Observatory. Retrieved from https://earthobservatory.nasa.gov/images/148866/research-shows-more-people-living-in-floodplains.

Fisher, K. (2021, October 1). *US inks $20 million deal to launch high-tech weather satellites in Space*. CNN. Retrieved from https://www.cnn.com/2021/09/30/world/us-weather-satellite-deal-scn/index.html.

Fortune Editors. (2021, October 25). *Pachama: 2021 Impact 20*. Fortune. Retrieved from https://fortune.com/impact20/2021/pachama/.

Freedman, A. (2021, September 9). *After Hurricane Ida, Flood Forecast System unveiled via Tomorrow.io*. Energy & Environment. Retrieved from https://www.axios.com/after-hurricane-ida-flood-forecasting-tomorrowio-3ee53579-4d13-41a9-9240-2b3f17713981.html.

Freedman, A. (2021, September 14). *Climate risk firm Jupiter Intel picks up major investor to jump-start an Asian expansion*. Energy & Environment. Retrieved from https://www.axios.com/climate-risk-jupiter-intel-mpower-partners-investment-513558ea-6dac-4317-af21-9c0a1b29fcbd.html.

Freedman, A. (2021, September 16). *Al Gore's climate trace tracking group finds vast undercounts of emissions*. Energy & Environment. Retrieved from https://www.axios.com/global-carbon-emissions-inventory-surprises-cb7f220a-6dfd-4f88-9349-5c9ffa0817e9.html.

Freedman, A., & Kokalitcheva, K. (2021, October 2). *The Next 30 Years of Extreme Weather* . Energy & Environment. Retrieved from https://www.axios.com/extreme-weather-next-30-years-910321ed-0457-4732-8f8a-24c001330413.html?deepdive=1.

Friedl, L. (2021, July 13th). Personal Communication.

Gallaudet, T. (2021, August 16th). Personal Communication.

Glasner, J. (2021, October 14). *Climate Software Startups are suddenly a hot investment*. Clean Tech and Energy. Retrieved from https://news.crunchbase.com/news/climate-software-startups-vc-investment-cleantech/.

GlobeNewswire News Room. (2021, June 15). *Pachama awarded as Technology Pioneer by World Economic Forum*. Pachama selected as most promising Technology Pioneer of 2021. Retrieved from https://www.globenewswire.com/en/news-release/2021/06/15/2246985/0/en/Pachama-Awarded-as-Technology-Pioneer-by-World-Economic-Forum.html.

Grinapol, C. (2021, March 15). *Matthew Eby: Providing vision and direction for a comprehensive flood model*. Engineering NewsRecord RSS. Retrieved from https://www.enr.com/articles/51047-matthew-eby-providing-vision-and-direction-for-a-comprehensive-flood-model.

Hammer, D. (2021, June 29th). Personal Communication.

Hammer, D. (n.d.). Dan Hammer. Retrieved from https://www.danham.me/r/.

Hicks, J. (2021 August 2nd). Personal Communication.

Hogan, J. (2020, April 14). *The Climate Service secures $3.825M series A financing round led by Persei Venture*. https://www.prnewswire.com/news-releases/the-climate-service-secures-3-825m-series-a-financing-round-led-by-persei-venture-301039710.html.

Hui, K. (2021, November 2). *The Lancet issues a 'code red' for climate change's health impact*. Health News. Retrieved from https://www.verywellhealth.com/report-signals-code-red-climate-change-5207916.

Invest or sell Orbital Insight Stock. Forge Global. (n.d.). Retrieved from https://forgeglobal.com/orbital-insight_stock/.

Irfan, U. (2021, October 15). *The $5 trillion Insurance Industry Faces a Reckoning. Blame Climate Change.* Vox. Retrieved from https://www.vox.com/22686124/climate-change-insurance-flood-wildfire-hurricane-risk.

Ivanova, I., & Layne, R. (2021, October 28). *Here's what every degree of heat rise could do to the global economy*. Retrieved from https://www.cbsnews.com/news/climate-change-heat-global-warming-economy/.

i3 Connect. (n.d.). *Pachama: Investment rounds, top customers, partners and investors* . i3 Connect. Retrieved from https://i3connect.com/company/pachama.

Jacobs, J. (2021, May 4). *Our investment in Pachama*. This Week in MCJ (My Climate Journey). Retrieved from https://myclimatejourney.substack.com/p/our-investment-in-pachama.

Jacobs, J. (2021, August 5). *Our investment in Cloud to Street*. This Week in MCJ (My Climate Journey). Retrieved from https://myclimatejourney.substack.com/p/our-investment-in-cloud-to-street.

John, M. (2021, November 5). *Explainer: Climate change: What are the Economic Stakes?* COP26. Retrieved from https://www.reuters.com/business/cop/climate-change-what-are-economic-stakes-2021-10-25/.

Jupiter Intelligence Company Information, funding & investors. Dealroom.co. (n.d.). Retrieved from https://app.dealroom.co/companies/jupiter_intelligence.

Jupiter. (2021, May 12). *About*. Jupiter. Retrieved from https://jupiterintel.com/about/.

Jupiter. (2021, October 21). *Jupiter announces $54 million in new funding*. GlobeNewswire News Room. Retrieved from https://www.globenewswire.com/news-release/2021/10/21/2318408/0/en/Jupiter-Announces-54-Million-in-New-Funding.html.

Kearns, E. (2021, August 10th). Personal Communication.

Kerber, R. (2021, September 16). *Al Gore-backed climate project to track emissions in real-time*. news.trust.org. Retrieved from https://news.trust.org/item/20210916040037-gtrv1/.

Kessler, J. (2021, July 22nd). Personal Communication.

Kobayashi-Solomon, E. (2020, October 28). *The Smart Money is Investing in Carbon Credits*. Sustainability. Retrieved from https://www.forbes.com/sites/erikkobayashisolomon/2020/10/28/the-smart-money-is-investing-in-carbon-credits/?sh=2afd554227e7.

Kontgis, C. (2021, June 25). *Mapping the world in unprecedented detail*. Retrieved from https://caitlin-kontgis.medium.com/mapping-the-world-in-unprecedented-detail-7c0513205b90.

Korber, R. (2021, June 28). *Breezometer Closes Series C with $30M for health-focused environmental intelligence*. BreezoMeter Closes Series C with $30M for Health-Focused Environmental Intelligence. Retrieved from https://blog.breezometer.com/breezometer-closes-series-c-with-30m.

Korber, R. (2021, September 1). *What's been happening at Breezometer since our funding announcement!?* What's Been Happening at BreezoMeter Since our Funding Announcement!? Retrieved from https://blog.breezometer.com/breezometer-2-months-after-fundraising.

Lardinois, F. (2021, March 30). *Weather Platform ClimaCell is now Tomorrow.io and Raises $77M*. TechCrunch. Retrieved from https://techcrunch.com/2021/03/30/weather-platform-climacell-is-now-tomorrow-io-and-raises-77m/.

The Leader in Geospatial Data Analytics. Orbital Insight. (n.d.). Retrieved from https://orbitalinsight.com/.

Lee, N. (2021, June 2). *135 million Americans are breathing unhealthy air, American Lung Association says*. CNBC. Retrieved from https://www.cnbc.com/2021/04/22/heres-how-many-americans-are-effected-by-air-pollution-every-year.html.

Lieberman, B. (2021, March 31). *Climate trace to track real-time global carbon emissions* . Yale Climate Connections. Retrieved from https://yaleclimateconnections.org/2020/08/climate-trace-to-track-real-time-global-carbon-emissions/.

Lin, R., & Fried, R. (2021, October 4). *State of the Water Industry 2021*. Nasdaq. Retrieved from https://www.nasdaq.com/articles/state-of-the-water-industry-2021-2021-10-04.

Lopes, M. (2021, August 9). *First Street partners with Pyregence Consortium to build first property specific, Climate adjusted fire risk model*. Press Release. Retrieved from https://firststreet.org/press/press-release-2021-pyregence-partnership/.

Lynch, D. J. (2021, October 2). *Inside America's Broken Supply Chain*. The Washington Post. Retrieved from https://www.washingtonpost.com/business/interactive/2021/supply-chain-issues/.

Marsh, A. (2021, October 14). *Ex-SEC head says climate disclosure support has 'skyrocketed'*. news.bloomberglaw.com. Retrieved from https://news.bloomberglaw.com/securities-law/ex-sec-head-says-climate-disclosure-support-has-skyrocketed.

Marshall, A., & Simon, M. (2021, September 6). *21st-century storms are overwhelming 20th-century cities*. Ars Technica. https://arstechnica-com.cdn.ampproject.org/c/s/arstechnica.com/science/2021/09/21st-century-storms-are-overwhelming-20th-century-cities/?amp=1.

Massback, K. (2021, July 8th). Personal Communication.

McCarthy, M. (2021, June 28). *Breezometer, the iPhone Tool that measures air quality, raises a $30M Series C*. TechCrunch. Retrieved from https://techcrunch.com/2021/06/28/breezometer-the-iphone-tool-that-measures-air-quality-raises-a-30m-series-c/.

Miglarese, A. (2021, July 21st). Personal Communication.

Moore, H. (2021, November 3). *Jupiter teams with the Arsht-Rock Center's extreme heat resilience initiative to support underserved countries and Communities*. GlobeNewswire News Room. Retrieved from https://www.globenewswire.com/news-release/2021/11/03/2326316/0/en/Jupiter-Teams-with-the-Arsht-Rock-Center-s-Extreme-Heat-Resilience-Initiative-To-Support-Underserved-Countries-and-Communities.html.

Moran, S. (2021, July 20th). Personal Communication.

National Association of Realtors. (2020, October 29). *Flood factor™ FAQ*. www.nar.realtor. Retrieved from https://www.nar.realtor/national-flood-insurance-program/flood-factor-faq.

National Oceanic and Atmospheric Administration. (2021, May). *NOAA Blue Book FY 2022*. Retrieved from https://www.noaa.gov/sites/default/files/2021-06/NOAABlueBook2022_final.pdf.

NASA. (2021, January 26). *NASA Earth Science Data Systems Program highlights 2020*. Earth Data: Open Access for Open Science. Retrieved from https://earthdata.nasa.gov/esds/nasa-esds-highlights-2020

Nelson, M. (2021, September 13). *Entrepreneurs Recognized for Innovations in Flood Mapping Technology*. ASU News. Retrieved from https://news.asu.edu/20210913-entrepreneurs-recognized-innovations-flood-mapping-technology.

Neuman, S. (2021, November 2). *Nations with 85% of Earth's forests pledge to reverse deforestation*. Special Series: The COP26 summit. Retrieved from https://www.npr.org/2021/11/02/1051390697/deforestation-forest-deal-cop25-amazon-brazil.

Nikkei Staff Writers. (2021, October 5). *Japan to require 4,000 companies to disclose climate risks*. Climate Change. Retrieved from https://asia.nikkei.com/Spotlight/Environment/Climate-Change/Japan-to-require-4-000-companies-to-disclose-climate-risks.

Nishant, N. (2021, December 7). *Weather security platform tomorrow.io to go public via $1.2 bln Spac deal*. U.S. Markets. Retrieved from https://www.reuters.com/markets/us/weather-security-platform-tomorrowio-go-public-via-12-bln-spac-deal-2021-12-07/.

NOAA. (2021). *Engagement*. Climate Program Office. Retrieved from https://cpo.noaa.gov/Meet-the-Divisions/Communication-Education-and-Engagement/Engagement.

NOAA. (n.d.). *Increasing U.S. communities' and businesses' resilience to extreme events*. Climate Program Office. Retrieved from https://cpo.noaa.gov/Funding-Opportunities/FY2019-Recipients/CEE/PID/7120/TagID/265/TagName/funding.

NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2021). https://www.ncdc.noaa.gov/billions/, DOI: 10.25921/stkw-7w73

Normand, A. E. (2021, November 4). *Landsat 9 and the future of the Sustainable Land Imaging ...* CRS Report Prepared for Members and Committees of Congress. Retrieved from https://crsreports.congress.gov/product/pdf/R/R46560.

O'Connell, K. (2021, August 4th). Personal Communication.

Olick, D. (2020, August 27). *Every American home is getting a flood-risk score – and many are at higher risk than previously known*. CNBC. Retrieved from https://www.cnbc.com/2020/08/26/every-us-home-gets-flood-risk-score-and-many-are-at-higher-risk.html.

Orbital Insight. (2021, August 18). *Orbital Insight Launches Supply Chain Intelligence solution to create end-to-end supply chain visibility and illuminate risk using AI*. https://www.prnewswire.com/news-releases/orbital-insight-launches-supply-chain-intelligence-solution-to-create-end-to-end-supply-chain-visibility-and-illuminate-risk-using-ai-301358035.html.

Orbital Insight. (n.d.). *Geospatial Technology Platform*. Platform: Orbital Insight GO. Retrieved from https://orbitalinsight.com/geospatial-technology.

Orbital insight: Most innovative company. Fast Company. (2021). https://www.fastcompany.com/company/orbital-insight.

O S Chegwidden, W R L Anderegg, G Badgley, D Cullenward, J A Abatzoglou, J A Hicke, A T Trugman, J Freeman, J Hamman (2020) "Risks to forest carbon in a changing climate" CarbonPlan https://carbonplan.org/research/forest-risks-explainer

Pearsall, M. (2021, July 23rd). Personal Communication.

Peters, A. (2021, March 9). *How AI Startup Pachama Brings Transparency to Carbon Offset Projects*. Most Innovative Companies. Retrieved from https://www.fastcompany.com/90600400/pachama-most-innovative-companies-2021.

Peters, A. (2021, September 16). *This Al Gore-backed project found that we're seriously undercounting greenhouse gas emissions*. Fast Company. Retrieved from https://www.fastcompany.com/90677559/this-al-gore-backed-project-found-that-were-seriously-undercounting-greenhouse-gas-emissions.

Peterson, B., & Naishadham, S. (2021, October 21). *NASA launches tool that measures Western Water Loss*. Hosted. Retrieved from https://hosted.ap.org/post-gazette/article/a2643c4b6a54b8842858248160dd07d3/nasa-launches-tool-measures-western-water-loss.

PitchBook. (n.d.). *Cloud to Street company profile: Valuation & investors*. Cloud to Street Overview. Retrieved from https://pitchbook.com/profiles/company/224060-59#investors.

Powell, K. (2021, October 7). *BreezoMeter Provides Outdoor Environmental Intelligence for Better In-Cabin Air Quality for Volvo Cars*. Yahoo! Finance. Retrieved from https://finance.yahoo.com/news/breezometer-provides-outdoor-environmental-intelligence-120600974.html?guccounter=1.

Products. Jupiter. (2021, October 21). Retrieved from https://jupiterintel.com/products/.

Pruchniewski, J. A. (2021, June 24). *Esri releases new 2020 global land cover map*. Retrieved from https://www.businesswire.com/news/home/20210624005176/en/Esri-Releases-New-2020-Global-Land-Cover-Map.

Rainbow, J. (2021, August 17). *Spire Global's Shares slip after first day of trading*. SpaceNews. https://spacenews.com/spire-globals-shares-slip-after-first-day-of-trading/.

Rajbjandari, A. (2021, September 28). *Climate Change Replaces Pandemic As Insurers' Biggest Worry*. Bloomberg Finance. Retrieved from https://www.bloomberg.com/news/articles/2021-09-28/climate-change-replaces-pandemic-as-insurers-biggest-worry.

Rice, D., & Tebor, C. (2021, October 11). *One-fourth of US infrastructure is at risk of floods. these 4 states are in the most peril.* USA Today. Retrieved from https://www.usatoday.com/story/news/nation/2021/10/11/infrastructure-risk-flooding-first-street-foundation-report/6050243001/.

The Rise Fund Announces $100 MILLION strategic investment in Climavision. Business Wire. (2021, June 2). https://www.businesswire.com/news/home/20210602005611/en/The-Rise-Fund-Announces-100-Million-Strategic-Investment-in-Climavision.

Rist, K. (2021, September 6). *How Geospatial Intelligence Startups are Transforming B2B Sectors*. Forbes. Retrieved from https://www.forbes.com/sites/kjartanrist/2021/09/06/how-geospatial-intelligence-startups-are-transforming-b2b-sectors/?sh=4b8753c92353.

Rott, N. (2021, October 20). *Climate change is bad for your health. and plans to boost economies may make it worse*. Climate. Retrieved from https://www.npr.org/2021/10/20/1047700783/climate-change-is-bad-for-your-health-and-plans-to-boost-economies-may-make-it-w.

Saez Gil, D. (2020, September 17). *Pachama welcomes amazing new investors to Support Our Mission*. Medium. Retrieved from https://pachamainc.medium.com/pachama-welcomes-amazing-new-investors-to-support-our-mission-a712224b2e1c.

Sanchez-Andrede Nuno, B. (2021, September 7th). Personal Communication.

Sarni, W. (2021, September 23rd). Personal Communication.

Sarni, W. (2021, April 22). *Tech and Innovation Offer Promise for the World's Most Water-Challenged Regions*. Editorial Events. Retrieved from https://techonomy.com/2021/04/investment-in-technology-and-innovation-offers-promise-for-the-worlds-most-water-challenged-regions/.

Schreiner, B., & Galofaro, C. (2021, December 14). *Tornado-slammed parts of Kentucky Face Long Recovery*. AP NEWS. Retrieved from https://apnews.com/article/tornadoes-business-kentucky-mayfield-abc2296191a26cb3487815093b689bc6

Scott, W. (2021, September 2nd). Personal Communication.

Shamah, D. (2015, May 10). *Israeli pollution app entrepreneurs to be feted at White House*. Current Top Stories. Retrieved from https://www.timesofisrael.com/israeli-pollution-app-entrepreneurs-to-be-feted-at-white-house/.

Shieber, J. (2020, April 14). *North Carolina-based The Climate Service raises $3.8 million for climate audits*. TechCrunch. Retrieved from https://techcrunch.com/2020/04/14/north-carolina-based-the-climate-service-raises-3-8-million-for-climate-audits/.

Shieber, J. (2021, April 30). *As concerns rise over forest carbon offsets, Pachama's verified offset marketplace gets $15 million*. TechCrunch. Retrieved from https://techcrunch.com/2021/04/30/as-concerns-rise-over-forest-carbon-offsets-pachamas-verified-offset-marketplace-gets-15-million/.

Shieber, J. (2021, March 9). *Mercado libre taps Pachama to monitor and manage its $8 million investment in Latin American rainforest restoration*. TechCrunch. Retrieved from https://techcrunch.com/2021/03/09/mercado-libre-taps-pachama-to-monitor-and-manage-its-8-million-investment-in-latin-american-rainforest-restoration/.

Skole, D. (2021, June 25th). Personal Communication.
Snell, N. (2021, July 27th). Personal Communication.

Stillman, D. (2021, August 24th). Personal Communication.

Stillman, D. (2021, November 16). *Tomorrow.io unveils global weather and climate security platform*. Tomorrow.io Post. Retrieved from https://www.tomorrow.io/blog/tomorrow-io-unveils-global-weather-and-climate-security-platform/.

St. John, J. (2020, July 15). *Climate TRACE: Using satellites and machine learning to pinpoint global emissions*. Energy. Retrieved from https://www.greentechmedia.com/articles/read/climatetrace-using-satellites-and-machine-learning-to-track-global-greenhouse-gas-emissions.

Sunkara, V. (2020, September 25). *Machine Learning Should Combat Climate Change*. Medium. Retrieved from https://medium.com/cloud-to-street/machine-learning-should-combat-climate-change-a38dcc2501d5.

Tachiiri, K., Su, X., & Matsumoto, K. (2021). *Identifying key processes and sectors in the interaction between climate and socio-economic systems: A review toward integrating earth–human systems.* Progress in Earth and Planetary Science, 8(1). https://doi.org/10.1186/s40645-021-00418-7

Tanner, M. (2021, July 19th and 22nd). Personal Communication.

Team. Jupiter. (2021, September 20). Retrieved from https://jupiterintel.com/team/.

Tellman, B., Sullivan, J.A., Kuhn, C. *et al.* Satellite imaging reveals increased proportion of population exposed to floods. *Nature* 596, 80–86 (2021).

TIME Magazine. (2020, November 19). *Climate TRACE: The 100 best inventions of 2020*. The Climate Cop: Climate TRACE. Retrieved from https://time.com/collection/best-inventions-2020/5911362/climate-trace/.

Toews, R. (2021, June 20). *These are the startups applying ai to tackle climate change*. Forbes. https://www.forbes.com/sites/robtoews/2021/06/20/these-are-the-startups-applying-ai-to-tackle-climate-change/?sh=3b906f3b7b26.

Tomorrow.io - funding, financials, valuation & investors. Crunchbase. (n.d.). Retrieved from https://www.crunchbase.com/organization/climacell/company_financials.

TripleByte. (n.d.). *Impact Observatory*. Software Engineering Jobs. Retrieved from https://triplebyte.com/company/public/impact-observatory.

True Elements. (2021, June 23). *Colorado River Basin first to benefit from strategic investment in water quality data.* Newsfeed. Retrieved from https://trueelements.com/newsfeed/colorado-river-basin-first-to-benefit-from-strategic-investment-in-water-quality-data/.

True Elements. (2021, May 13). *True Elements Joins the Global Water Council*. Newsfeed. Retrieved from https://trueelements.com/newsfeed/true-elements-joins-the-global-water-council/.

True Elements. (2021, October 6). *Water Quality Data & Forecasting*. Home: True Elements. Retrieved from https://trueelements.com/.

Thomas, W. (2021, July 2). *FY22 budget request: NASA*. Science Policy News from AIP. Retrieved from https://www.aip.org/fyi/2021/fy22-budget-request-nasa.

Tucker, P. (2021, September 2). *Was Russia's April exercise a practice run for a Ukraine invasion?* Science & Tech. Retrieved from https://www.defenseone.com/technology/2021/09/russias-april-exercise-crimea-may-have-been-ukraine-invasion-practice-run/185082/.

Udasin, S. (2015, May 12). *Founders of israeli air pollution app breezometer attend White House*. Business & Innovation. Retrieved from https://www.jpost.com/business-and-innovation/tech/founders-of-israeli-air-pollution-app-breezometer-attend-white-house-402867.

UN Environment Programme. (n.d.). *The six-sector solution to the Climate Crisis*. EXTRAPOLATED FROM UNEP'S 2020 EDITION OF THE EMISSIONS GAP REPORT. Retrieved from https://www.unep.org/interactive/six-sector-solution-climate-change/.

U.S. Climate Resilience Toolkit. U.S. Climate Resilience Toolkit | U.S. Climate Resilience Toolkit. (n.d.). Retrieved from https://toolkit.climate.gov/#steps.

U.S. Geological Survey. (2021, May 28). *FY 2022 Interior Budget in Brief, U.S. Geological Survey*. Retrieved from https://www.doi.gov/sites/doi.gov/files/fy2022-bib-bh059.pdf.

USGS. (n.d.). *Hydrologic Unit Maps*. USGS Water Resources: About USGS Water Resources. Retrieved from https://water.usgs.gov/GIS/huc.html.

USGS. (n.d.). *What is continuous real-time water quality (RTWQ)?* Real-time water quality. Retrieved from https://waterwatch.usgs.gov/wqwatch/faq?faq_id=1.

Walsh, P. (2021, July 28th). Personal Communication.

Weatherhead, B. (2021, November 1). *The science everyone needs to know about climate change, in 6 charts*. Entrepreneur. Retrieved from https://www.entrepreneur.com/article/394688.

Welcome to Tomorrow.io. Tomorrowio. (n.d.). Retrieved from https://www.tomorrow.io/company/.

Werner, D. (2021, October 1). *Tomorrow.io wins Air Force funding for weather satellite constellation*. Retrieved from https://spacenews.com/tomrorow-io-wins-air-force-contract/.

Wolfrom, J. (2021, September 22). *Local startups remove carbon from the atmosphere-but is it an effective approach?* News/Newsletter/The City. Retrieved from https://www.sfexaminer.com/news/local-startups-remove-carbon-from-the-atmosphere-but-is-it-an-effective-approach/.

World Bank. (2019, August 20). *Quality Unknown: The Invisible Water Crisis*. Feature Story. Retrieved from https://www.worldbank.org/en/news/feature/2019/08/20/quality-unknown.

World Health Organization. (2021, September 22). *NEW WHO global air quality guidelines aim to save millions of lives from Air Pollution*. World Health Organization. Retrieved from https://www.who.int/news/item/22-09-2021-new-who-global-air-quality-guidelines-aim-to-save-millions-of-lives-from-air-pollution.

Worland, J. (2020, July 16). *Al Gore's new project, 'climate trace,' will track emissions*. Science Climate Change. Retrieved from https://time.com/5866881/al-gore-climate-trace-emissions/.

Wrogel, S. (2021, October 13). *With tools tracking air pollution, Israeli start-up hopes to 'democratize environmental data'*. Retrieved from https://www.algemeiner.com/2021/10/13/with-tools-tracking-air-pollution-israeli-start-up-hopes-to-democratize-environmental-data/.

Zrebiec, A. (2021, September 17). *Johns Hopkins APL Scientists contribute award-winning breakthrough to Ai-Driven climate initiative*. The Applied Physics Laboratory. Retrieved from https://www.jhuapl.edu/PressRelease/210917-apl-climate-trace-team-wins-award.

6 companies Harnessing satellites for water. Aquatech. (2020, October 21). https://www.aquatechtrade.com/news/utilities/6-companies-harnessing-satellites-for-water/